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# The Wrong Right Stuff: Why NASA Consistently Fails at Congress

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# **The Wrong Right Stuff: Why NASA Consistently Fails at Congress**

A thesis submitted in partial fulfillment of the requirement  
for the degree of Bachelors of Arts in Government from  
The College of William and Mary

by  
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Accepted for \_\_\_\_\_.

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**May 3, 2013**

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## **Part 1: Introduction and Background**

Around the beginning of the 20th century, Earth seemingly got smaller as frontiers grew into new cities. In the middle of this century, many on both sides of the Iron Curtain realized that a positive future for humanity in general and their nation in particular could come from the exploration of space. This led to the “Space Race” which culminated in July of 1969 when men from Earth first set foot upon the Moon. They came in peace for all mankind and they were Americans. In retrospect, the nation, as a whole, strongly supported the Apollo program; President Kennedy, who was perceived as Apollo’s leading proponent, is now hailed as a great visionary and the program itself is considered one of the greatest technological achievements in history. Directly after Apollo, millions of Americans thought that “one small step” would be simply the start of an endless age of exploration. After all, NASA was projecting that Americans would be on Mars by 1980, Saturn by 1990, and Alpha Centauri by the year 2000. However, millions were disappointed when NASA followed the policy of President Nixon and retreated to low Earth orbit to focus on the construction of the International Space Station and the Space Shuttle program. The public good will behind the Apollo programs transferred over to the Shuttle, which was supposed to become the new high watermark for NASA, and human achievement.

However, since the Shuttle program was inherently more politicized than the original Apollo, Mercury, and Gemini missions, NASA’s human spaceflight program has lacked a clear direction. Thus, it has achieved comparatively little in the 40 years since

the Apollo program, despite the dramatic pace of technological advancement in other areas. Today, the American space agency has mostly lost its way. The era of the Shuttle has ended and the Shuttle replacement program, Constellation, was utterly scrapped with only a single unmanned, suborbital test flight to show for it. NASA, supposedly the guardian of the world's most technologically advanced civilization, can no longer put men into space without the help of the Russians. NASA has plenty of plans to fix this...but they cannot afford any of them. These recent disappointments, combined with other factors, have led to a dramatic lack of political will around the issue of space exploration.

Two different American Presidents since Kennedy have attempted to renew the vision of NASA by setting their sights on the next logical step for human space flight, Mars. The Red Planet has everything a human mission could ever need: geothermal energy, water, carbon, oxygen, nitrogen, a weak magnetic field, complex geology which created mineral ore, and even the convenience of a nearly 24 hour day. Mars is a place where humanity could visit or even potentially settle. Technologically, America is far more prepared to visit Mars today than it was to visit the Moon directly after President Kennedy's commitment.

The only serious obstacles to an American Mars mission or a more general expansion of the space program are political in nature. Acquiring sufficient funding for such a program through the appropriations processes of Congress has proven to be much more difficult than actually getting a manned spacecraft to Mars. Therefore, it is

highly instructive to examine the failures of the various successive NASA programs to obtain adequate Congressional funding to achieve their stated mission goals. Programs like George Bush Senior's Space Exploration Initiative (SEI), George Bush Junior's Vision for Space Exploration (VSE), and the Space Shuttle Program, which were mostly failed programs, can be contrasted with the obvious success of the Kennedy/Johnson Apollo initiative and NASA unmanned space programs. This may suggest a great deal about how to get budgets through Congress. This thesis will attempt to prove that the reasons for rejecting SEI, VSE, and other potential overhauls of the space program were not the scientific challenges of interplanetary spaceflight, but rather a lack of political will and the inability of the United States Congress and Executive Branch to make long-term, large scale investments, despite much rhetoric to the contrary. This will begin with a review of the history of the failed initiatives, and then examine successful major NASA programs to explore why they succeeded in garnering the support necessary to have a shot at their objective. As *The Right Stuff* once pointed out, "No bucks, no Buck Rogers."

The process in funding a NASA mission can be broadly divided into pre-Soviet collapse and post-Soviet collapse which are based on a variety of factors that affect the strength of a President's commitment and the strength of his resistance in Congress.

These include, but are not limited to:

- The relative cost of the mission compared to past NASA missions. Generally speaking, programs with lower upfront costs tend to decrease the resistance of Congress, since each Congressional representative has an incentive to channel

funds away from discretionary programs and towards their district. This means that lower costs directly translate to easier passage through Congress and increase the ability of the President to actively get behind a program.

- The time horizon of the mission compared to past missions.

Put simply, missions are vulnerable to cancellation for budgetary reasons until they demonstrate tangible results which the average American can hear about from media sources. Additionally, most Congressional appropriations are set up so that they either require reauthorization or are vulnerable to cancellation in each new Congress. A new President or new Congress will often not be as politically connected to a mission as the administration which proposed it. Historically speaking, new Presidents frequently dismantle the space policy of the previous President. The shorter the time horizon, the greater the odds of a program successfully navigating the budgetary gauntlet of the internal NASA bureaucracy and Congress; shorter programs are simply more successful.

- The technical complexity of the mission.

Less technically complex programs are inherently more understandable to Congressional representatives voting on them. Congressmen don't like spending money when they don't understand the expenditure. Additionally, programs which are less technically complex tend to contain fewer "white elephants" and are thus cheaper. Therefore, simpler missions are far more likely to succeed.



- NASA's status in relation to the Defense Department and the ability of the President to exploit that fact as a means of fundraising.

Most Congressional legislators consider supporting NASA to be either pro-defense or pro-education. Since defense spending is a much more substantial portion of the budget than education spending, if the President can sell NASA as a defense program, Congress is much more likely to go along with it and back the program.

- The President's ability to control Congress via personal charisma or party loyalty.

Not all Presidents are created equal when it comes to getting Congress to do what they want. A Congress which is more cooperative with the President for whatever reason is more likely to pass that President's agenda. This means that big changes for NASA are most likely to occur when the same political party holds the Presidency and both Houses of Congress. Conversely, a divided government is less helpful to NASA from a funding perspective, since it inherently leads to partisan bickering.

- The nature of the decreasing discretionary federal budget.

Due to the rapidly changing spending priorities of the federal government, which are currently focusing on mandatory spending programs like Medicare, Medicaid, and Social Security over discretionary spending programs, there is less

“free money” for the various discretionary agencies like NASA, Housing and Urban Development, Department of Education, and the National Achieves.

- The highly over-publicized failures of NASA.

In recent years NASA has suffered several major setbacks due to the inherent difficulties of space explorations. Some of these setbacks rapidly became media circuses due to the costs involved and the obvious human tragedy. Congress is generally unwilling to give additional funding to agencies that have such public, and media- catching failures. This is even truer when the failure is something which is comprehensible to the average voter or Congressman, like \$640 million dollar Mars Climate Orbiter crashing due to a failure to convert from US Customary to Metric. These errors decrease NASA’s prestige drastically, which makes it harder to obtain financial backing from Congress.

- Public opinion shows NASA suffers from a dramatic lack of public support among many constituencies of the electorate while simultaneously suffering the stigma of being presumed to cost far more than it actually does.

Congressmen are very unlikely to vote for programs which are perceived not to benefit their constituents very much.

- NASA’s tendency to design its missions and vehicles to appeal to the broadest possible spectrum of funding sources.

This ultimately leads to “design by committee” and “gold plating” systems which both increase the cost of the mission/vehicle and the chances of a dramatic mission failure.

- The inability of NASA to remain a budgetary priority after the fall of the Soviet Union.

The largest relative budgets in NASA history were during the “Space Race.” NASA was widely seen to be the guardian of the Free World’s technical expertise and to be locked in an eternal struggle with the Soviet Union. Today, no other true “competitors” exist with which NASA can engage in a space race. After the passing era of the need to “keep up with the Commies,” NASA has become an increasingly neglected agency of the federal government.

- NASA’s failure to effectively sell the program of manned space flight due to other priorities.

In recent years, NASA has been mandated by various Congresses and Executives to do things far outside of its traditional jurisdiction. Simultaneously, NASA failed to advertise its accomplishments in a way which reached a widespread audience. This led to decreased public support and decreased interest, which in turn led to fundraising issues over a long period of time.

- NASA's remarkable advances in the technology for unmanned spaceflight which has the potential to be cheaper, less dangerous to human life, and capable of performing missions which humans never could.

This has led to a decreasing interest in the astronaut program by Congress and American citizens. Robotic missions are simply not as glamorous as manned spaceflight and lack the "human angle."

- NASA's present lack of a clear destination/goal and regularly engages in internal bureaucratic infighting between various internal factions over what said destination/goal should actually be.

These various factions often enlist Congressional support by criticizing each other's mission plans very publically. This makes it easy for individual Congressmen to find qualified interagency dissent, which makes it less likely that any faction will get funded. The only apparent way to get round this is by only proposing very large programs which include every faction's pet technology. However, such projects are always incredibly expensive and have long time horizons, which make Congress much less likely to fund them.

- NASA "complacency" with its role as a tertiary agency and as a common target for budgetary cuts.

In more than 40 years since the Apollo program, NASA has only made two serious attempts to dramatically increase its funding by getting seriously involved in the

political process. If this is contrasted with other agencies of similar size and scope, such as the EPA, it is entirely understandable that the “squeaky wheel gets the grease” when it comes to inevitable interagency bureaucratic infighting. So far, NASA has been a remarkably “unsqueaky” wheel.

- Finally, the persistent Moon landing conspiracy theory which denies that NASA’s greatest accomplishment ever actually occurred. Statistically speaking, the individuals most likely to believe this conspiracy theory are the recently empowered “Youth Voters.” The widespread prevalence of the theory assures that it has some political impact, as individuals who doubt the Moon landing are obviously far less likely to support space exploration.

Additionally, an attempt will be made to determine where each American space program went wrong and how future spaceflight missions to Mars could be achieved in a politically survivable way. As President George Bush Senior said, “It is humanity’s destiny to explore and America’s destiny to lead” (Bush, 1982). However, what the President didn’t realize is that it is the destiny of Congress to stop innovative and potentially risky programs that fail to be adequately justified and defended during the appropriations process.

### **Pre-Soviet Collapse: Early American Failures in Space**

In 1955, both the USA and the USSR announced they would launch satellites into orbit around the Earth in the near future. The initial launch of Sputnik ignited public controversy and outrage in the United States. Sputnik caused Eisenhower to order Project Vanguard, a plan to put an American satellite into space, to significantly move up its timetable. This panicked reaction by the US Government, coupled with the political selection of Vanguard as a launch vehicle, which will be further discussed later, led to a remarkably high 72% failure rate among Vanguard launches, all of which were broadcast into American living rooms by television (Vanguard, 2012).

Vanguard Name	Launch Date	Result
Vanguard TV3	12/6/1957	Failed to orbit
Vanguard Backup	2/5/1958	Failed to orbit
Vanguard 1	3/17/1958	Orbited successfully
Vanguard TV5	4/28/1958	Failed to orbit
Vanguard SLV 1	5/27/1958	Failed to orbit
Vanguard SLV 2	6/26/1958	Failed to orbit
Vanguard SLV 3	9/26/1958	Failed to orbit
Vanguard 2	2/17/1959	Orbited successfully
Vanguard SLV 5	4/13/1959	Failed to orbit
Vanguard SLV 6	6/22/1959	Failed to orbit
Vanguard 3	9/18/1959	Orbited successfully

(Figure 1) Graph Created Using Data from (Vanguard, 2012)

The Vanguard rockets were an absolute failure for technical and internal political reasons, despite the fact that they were remarkably well-funded. This demonstrated that a bad idea can easily create a high monetary “opportunity cost” in NASA. When Project Vanguard switched rockets from the Vanguard rocket to the Juno 1 rocket, which was essentially a “civilian” copy of a military missile, the project started to achieve greater success. In fact, despite being overshadowed by Sputnik and the absolute national humiliation of the early Vanguard rockets, by using military grade Juno rockets, Project Vanguard eventually accomplished most of its scientific objectives. This proved that with enough money and good engineering, it is possible to salvage a bad program. Vanguard’s greatest accomplishment was the start of the Explorer Program with the launch of Explorer 1 on January 1<sup>st</sup> of 1958 using the modified Juno rocket (Dickson, 2001). For several years both the Soviets and the United States continued throwing satellites and small animals into orbit...then the unthinkable happened.

Yuri Gagarin, riding the Soviet rocket *Vostok 1*, became the first man in space on April 12, 1961. Reaction in America was fierce and somewhat terrified despite the fact that Alan Shepard rode *Freedom 7* into space, but not into orbit, on May 5, 1961 less than a month later. Less than two weeks after Gagarin’s flight, Vice President Lyndon Johnson urged President Kennedy to accelerate the American space program and make its goal the Moon, since that goal was sufficiently distant to allow the American space program to catch up to the Soviets. It is important to note that the Soviet space initiative actually was much less technically sophisticated than America’s in essentially every non-rocketry area of both respective programs. The United States was far ahead



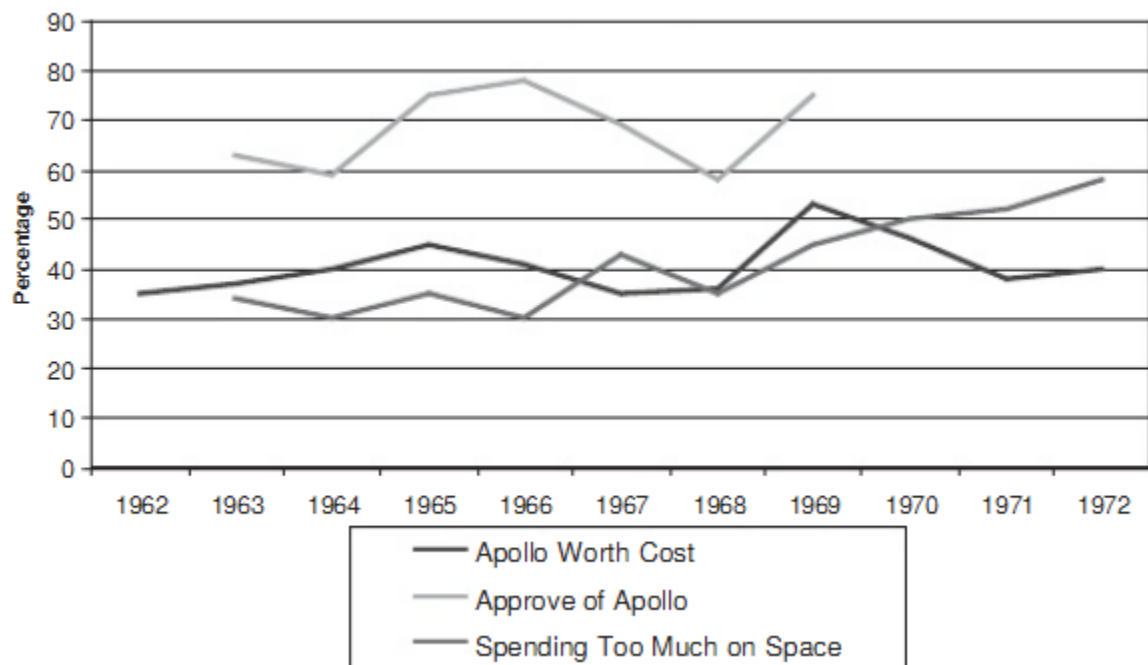
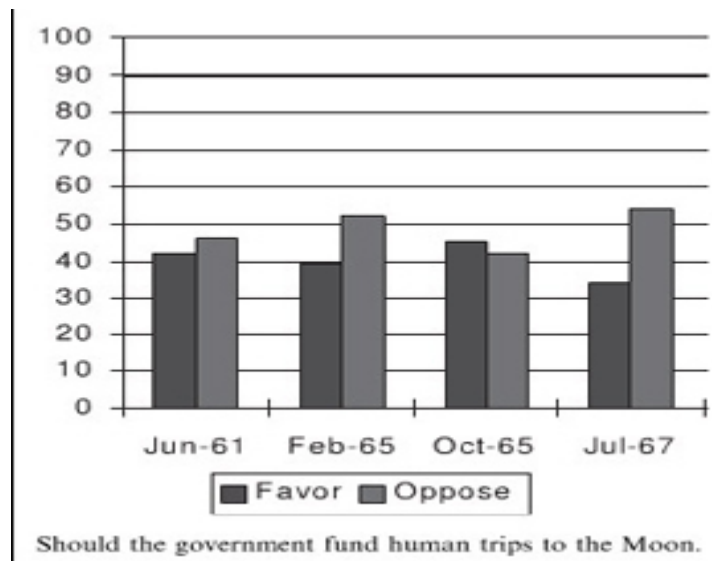
of the Soviet Union in sciences like chemistry, electronics, and metallurgy, all of which would be needed during a Moon landing. At the time, American leadership knew that the USSR had little chance of successfully landing a man on the Moon before the United States. Therefore, Johnson and Kennedy agreed to make the Moon their long-term goal since the program stood a good chance of beating the Soviets to the Moon, although America couldn't possibly beat them in the near term (Johnson and Welsh 1961). Despite the outspoken objections of Jerome Weisner, a former Eisenhower Presidential Science Advisor, and largely thanks to the unfailing support of NASA Administrator James Webb and Deputy NASA Administrator Hugh Dryden, President Kennedy agreed to make the Moon the target of NASA (Hanks, et.al, 1998). President Kennedy then shared his vision in a special joint session of Congress on May 25, 1961 before any American had even orbited the Earth. This speech marked the true start of the Apollo Program.

### **Pre Soviet Collapse: The Successful Mercury, Gemini, and Apollo Programs**

Kennedy's speech led to a redoubled effort on the part of the newly focused NASA. The center of this plan was based around "checking off" numerous technical capabilities which would need to be demonstrated before a Moon landing could be attempted with a reasonable chance of success. This list of technical capabilities recognized that NASA would need to learn how to: maintain an orbit, develop capabilities working outside of the crew vehicle, rendezvous with other spacecraft, dock with other spacecraft, and most importantly keep a man alive on the moon for an indefinite period of time (Hanks, et.al, 1998). Learning to maintain an orbit was largely figured out during the Mercury Program which was responsible for Sheppard's flight (Schefter, 1999). This program lasted until 1963 when it was replaced by the Gemini Program which was tasked with acquiring the technical expertise required for both extra-vehicular operations and the rendezvous and docking requirements. Much of the development of the long-duration medical expertise was rushed towards the end of the program. In fact, research into this area still continues today (Hanks, et.al, 1998). While NASA was gearing up to begin the Gemini and Apollo programs, Kennedy and Johnson were busy building the necessary political support. In his "We Choose to go to the Moon" speech, given at Rice University on September 12, 1962, Kennedy rededicated himself and Johnson to politically supporting the fledgling space program.

It is important to remember that Kennedy's program was not popular when it was initially proposed and many people who approved of Apollo didn't believe it was worth the cost as demonstrated in the graphs below (Launius, 2003). In fact, even after Apollo

11 landed, only 53% of Americans thought it was “worth the cost” (Strauss, 2011).



Graphs taken from (Launius, 2003).

However, the political posturing of the Johnson administration was quickly overshadowed by the USSR's remarkable achievement of Alexi Leonov's first space-walk on March 18, 1965. This, and subsequent Soviet propaganda announcements, further indicated to the United States that the Soviets had their eyes on a "Red Moon." On June 3, 1965, the first American space-walk was performed by Gemini 4's Edward White after the craft had already circled Earth 66 times in four days. This event marked the turning point in the Space Race. White's space-walk lasted twice as long as Leonov's and required a much greater degree of technical sophistication. After this event, the eventual outcome of the space-race was no longer in doubt and future milestones in space were almost always reached by Americans first. For example, the first space docking was achieved by the United States on March 16, 1966, by Gemini 8 under the command of Neil Armstrong. It took several attempts and a lengthy delay until the USSR matched that feat on January 16, 1969. By that point, the Soviet Union was simply too far behind to catch up, unless something catastrophic happened to the American space program. Sadly, something catastrophic did happen.

During a routine test, a tragic fire in Apollo 1 caused the death of three astronauts, all of whom had played critical roles in the Mercury and Gemini programs (Hanks, 1999). This event devastated America's space community and led to multiple Congressional investigations. This event also led to a lengthy redesign effort that removed flammable materials from the cockpit and replaced the astronauts' space suits to make them more flame resistant. Making the Apollo capsule more fire resistant

consumed NASA for around one year and provided the potential for the Soviet Union to catch up. In 1967, the Soviets were actually planning to land on the Moon in September of 1968. At this point, Apollo 7 was scheduled for launch in October of 1968 and wasn't planned to land on the Moon, so real concern existed in NASA that the Russians might win due to the Apollo 1 disaster (McDougall, 1985). Two different groups of cosmonauts, headed by Yuri Gagarin and Alexi Leonov respectively, were revealed to be training for a lunar mission. This kicked NASA's program out of the safety phase and back into high gear. After the fall of the Iron Curtain, however, it was revealed that the USSR had only managed to stay competitive with the United States by cutting corners and covering up the resulting failures. In fact, cosmonauts had a habit of mysteriously "disappearing" from official Soviet propaganda photos. Additionally, a documented case exists where NASA officials detected Soviet spacecraft's disintegration on reentry to the atmosphere; numerous rumors of "Lost Cosmonauts" circle the former Soviet Union to this day (Krulwich, 2012). Clearly, the Soviet Union simply never had a real chance of beating the US to the Moon, even considering the setback caused by the Apollo 1 fire.

After the complete redesign, Apollo 7 was launched on October 11, 1968; to complete Apollo 1's original mission of checking out the capsule in Earth orbit. The crew spent 11 days in space and was remarkably effective. However, quite a few other milestone events were happening in 1968 and public interest in the space program started to wane due to the Vietnam War, the Civil Rights Movement, the assassination of RFK&MLK, and the rioting at the 1968 Democratic National Convention. But on December 21, 1968, the Apollo program recaptured the public eye again with the launch

of Apollo 8. It took three days to travel to the Moon and orbited it ten times over 20 hours. The defining moment of the mission occurred on December 24<sup>th</sup> when astronaut William Anders snapped the famous photo “Earthrise” (McDougall, 1985). Later, 1969 saw the ultimate culmination of the space program in Apollo 11 which landed on the Moon on July 20, 1969. However, ironically, Apollo 11 effectively ended the Space Race; immediately afterwards President Richard Nixon began directing resources away from the Apollo program. The Apollo 13 disaster, despite the fact that no astronaut died, further diverted funding and led to the cancellation of future Apollo missions. Apollo’s 12, 14, 15, 16, and 17 all landed on the Moon successfully, but the program was cut shortly thereafter, at the urging of President Nixon so that its budget and resources could be used to finance the upcoming Space Shuttle and Skylab programs. Apollo was remarkably successful both at meeting its mission objectives on time and in procuring the budget necessary to meet those objectives. The reasons Apollo succeeded are complex and varied. It certainly had the anti-Soviet “Space Race” nationalism going for it, but it also was technically simple, short term and relatively economical for its time.

### **Pre Soviet Collapse: The Quasi-Successful Shuttle Program**

America's Space Shuttle program got underway during the closing days of Apollo; it originally was intended to make space travel easy, routine, standardized, and affordable. It failed spectacularly on all accounts. By the time of its decommissioning, the Shuttle Program ended up costing 209 billion dollars, over 20 times the original projection. The Shuttle, however, was remarkably successful in acquiring the money needed to run the program, despite the relative lack of success and highly publicized disasters; largely due to political compromises which will be discussed later.

Paradoxically, such bartering was at least partially to blame for the program's issues in the first place. Due to these compromises, criticizing the Shuttle became an entangled political nightmare; therefore, it was never really questioned (Jurist, Dinkin, and Livingston, 2005).

As the Apollo Program reached its crescendo, Vice President Agnew chaired a committee attempting to determine the future goals of NASA. They considered a mission to Mars, following up on the Apollo program, investing in low-Earth orbital infrastructure, and simply stopping all space activities. Ultimately, President Nixon followed the committee's recommendation to create a network of satellites and space stations based around a reusable orbital vehicle to defer the high costs inherent in lifting anything to orbit ("Report," 1969). To further cut costs, Congress encouraged the military and various intelligence agencies to also use the Shuttle. Both stakeholders wanted a very large Shuttle so they could launch very large satellites easily. In space

systems, cost is very closely related to weight, so a larger system would be far more costly. Other debates about full versus partial reusability took place too, which will be addressed later in this thesis. A far larger proportion of Americans than ever supported the Apollo program believed that the Space Shuttle was a good investment, despite the lack of actual achievement in the Shuttle program (Launius, 2003). Essentially, despite the relative lack of “cutting-edginess” and general lack of scientific merit, the Space Shuttle was a political hit with both various governmental organizations and the general public simply because it was opposed by virtually no federal agencies. Everyone who mattered was already highly supportive of the shuttle.



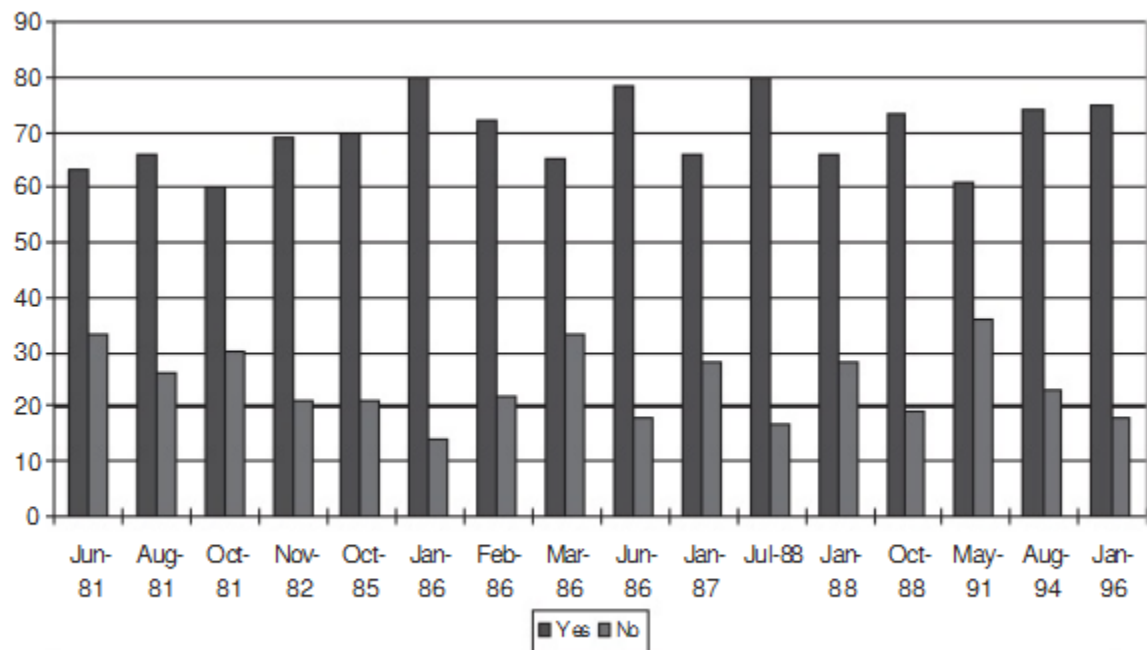


Fig. 7. Is the space shuttle a good investment.

Graph courtesy of (Launius, 2003)

The Shuttle program really began on September 17, 1976 when the prototype Space Shuttle *Enterprise* was displayed to an admiring world. However, the first orbital flight of the new Shuttles did not occur until April 12, 1981. This incredibly extended time delay between major events and launches would go on to characterize the program. Simply put, the Shuttle wasn't as "fast paced" as it was supposed to be or as the Apollo program which preceded it. Launches were still considered to be a major point of national pride, but never so much as the Apollo program. The Shuttle continued for a remarkably long time in the terms of NASA stretching from its first launch in 1981 through the fall of the Soviet Union until 2011. In the 135 Space Shuttle launches, tragically it failed twice: one launch failure with *Challenger*, and one re-entry failure with *Columbia*. That meant the program had a failure rate around 1.5%, far above the failure rates of military aircraft and manned "single shot" launch vehicles. It is worth noting that the failure rate of unmanned probes is far above that of manned spacecraft. One of the primary reasons for such a high rate of failure is the politicized nature of the design, stemming from the less reliable solid rocket boosters which will be discussed later. Both Shuttle disasters have been traced to the solid fuel tank connected to the solid rocket boosters. In the case of the *Challenger*, the problem was with the O-ring connecting the two stages, while with the *Columbia*, the problem was from a damaged fuel tank when a piece of the tank broke off and disrupted the heat shield (Columbia, 2003). Therefore, it is not unreasonable to say that the politics of the Space Shuttle's design process resulted in the deaths of 14 astronauts due to the selection of a cheaper and inferior solid fuel system.

The fact that the Shuttle utterly failed to achieve its stated goal of reducing the transportation cost per pound lifted into orbit further argues against political compromise as a means for NASA to get funding, as will be discussed later (Whittle, 2011).

## **Part 2: The Thin Years, Repeated Failure in NASA in the Post-Soviet Era**

After the USSR fell apart in the early 1990's, no country existed which could "challenge" the United States to a real space race. This meant that a huge reason for investing in NASA disappeared. Since the fall of the USSR, the NASA budget for manned spaceflight has fallen every year. The only exceptions were the two great attempts to push humanity to Mars, the Space Exploration Initiative and the Vision for Space Exploration (Zubrin and Wagner, 2011). Ultimately the presence of the Soviet Union as a major "competitor" with the United States encouraged America to invest heavily in space. With the collapse of the USSR, the "incentive" to "win the race" had effectively been eliminated.

### **The Failure of the Space Exploration Initiative:**

The first large post-Soviet NASA program and the first of NASA's absolute failures was the Space Exploration Initiative. The Initiative began on July 20 of 1989, when President Bush Senior stood on the steps of the Air and Space Museum flanked by the veterans of Apollo 11. Bush committed the nation to a sustained program of space exploration culminating in the settlement of space (Bush, 1989). NASA planned to execute this goal by creating the massive Space Station *Freedom* as a staging ground for a build-up of space-based infrastructure to send astronauts back to the Moon to stay. The astronauts would build a massive lunar base for eventual construction of the 1,000 ton spaceship for a Mars voyage based on a nonexistent propulsion system entirely different from that of the lunar shuttles. After this massive construction program, the ship would launch for Mars, travel for months, and eventually land a small crew on Mars for about two weeks to plant the American flag (Report, 1989). Due to the complexity of the plan, the massive spaceship, and the fact that it was essentially a wish list where every existing, planned, conceived, or desired NASA technology project was deemed "mission critical," the plan was dubbed "Battlestar Galactica" by its detractors (Zubrin and Wagner, 2011). The total cost estimate was approximately 500 billion in 1990 dollars; spread over 20 to 30 years, and the program was structured so the burden of actually funding it would fall on the next administration, even if Bush was re-elected (Dick, 2008). This would establish the program as the largest single government expenditure since the Second World War.

Openly disgusted by such massive long-term spending, eager to support NASA's still operating non-SEI Space Shuttle program which just happened to mostly operate out of Maryland's Goddard Spaceflight Center, and possibly seeing an opportunity to embarrass the Bush administration during the 1992 election year, Senator Barbara Mikulski (D-Maryland) went on an anti-SEI witch-hunt in the 1991 and 1992 NASA budgets. She attacked virtually anything remotely attached to the Space Exploration Initiative and basically singlehandedly killed the program (Dinnerman, 2010). Eventually, no SEI funding was capable of passing through the Appropriations Committee. Mikulski effectively destroyed SEI support via her committee seat, while allowing Shuttle funds to pass through unhindered. This blocking of critical appropriations at the committee level led to the SEI program's ultimate failure. However, even without Mikulski's attacks, the 500 billion dollar price tag would almost certainly have doomed any major space project, since Congress is rarely willing to allocate funding on that scale. One of the primary reasons SEI failed was the massive fiscal investment stretched out over such a long time period, which made it politically vulnerable. Effectively, the Space Exploration Initiative was forced to play Russian roulette every year to maintain funding levels. SEI was a large program which didn't produce many discernible results. It was also closely associated with a relatively weak President whose party lacked control of Congress in an election year. Therefore, SEI could only get lucky so many times. The failure of the program is almost certainly traceable to its long time horizons and extremely high cost. Congress simply does not allocate large amounts of money to "risky" NASA programs over 30 year time periods.

### **The Failed Vision for Space Exploration:**

Another example of a program incapable of surviving the political gauntlet required to maintain funding levels was President Bush Junior's Vision for Space Exploration. This new program was initially in a much better fiscal position than SEI due to technological advances which caused it to be much safer and elimination of some of the technical issues that had plagued the SEI. This led to mission architecture for the program which was far simpler, thus enabling dramatic cost reductions and a greater margin for astronaut safety. These factors reduced the cost of the mission to 230 billion dollars over about 20 years (Boehlert and Gordon, 2006). Furthermore, Congressional Republicans narrowly controlled both the House of Representatives and the Senate, so the administration could hypothetically ensure funding of the program until it produced real results. This potentially made it politically more difficult to cancel for the next administration. However, when the Democrats regained control of Congress in 2006, funding for VSE's programs immediately became problematic. The Democrats slashed funding of the Constellation project and the Ares boosters which were the heart of the Vision for Space Exploration. They then slashed other ambitious aspects, devolving the program into what was essentially a return to the Moon (Zubrin and Wagner, 2011).

Then when President Obama entered office, an enormous lobbying effort to save Constellation began. This effort even persuaded normally reticent astronaut Neil Armstrong to testify before Congress to attempt to save Constellation, labeling opposing

arguments as “mystifying” (Armstrong, 2010). However, under the directive of President Obama, the Democrats destroyed Constellation after most of its money was already spent and stripped America of its ability to even access space. Remarkably, this was done without saving any expenditures, since most of NASA’s funding was diverted into various make-work projects: refurbishing the shuttle launch pads after the shuttle had exited service, developing the VASMIR electric thruster without building the nuclear reactors required to power it, and changing the Orion capsule to an orbital descent vehicle without a way to get the capsule into space. Congress was so stunned by this lack of leadership that a bipartisan group of Congressman, Senators, and industry experts formed a coalition in an attempt to save some aspects of Constellation (Zubrin and Wagner, 2011). However, the majority of the program was scrapped to make way for an increased NASA focus on environmental science and a potential voyage to a Near-Earth Asteroid which most analyst believe is doomed to fail largely due to the long time horizon. As of the time of this writing, the Obama administration has failed to either continue Constellation or start the design and construction of a viable alternative.



### **The Success of Unmanned Space Flight:**

After the *Challenger* disaster, NASA attempted to become much more safety conscious. Since the Space Shuttle had obvious design flaws and wasn't capable of leaving Earth orbit, NASA engineers decided to take a new approach to fit their new "faster, better, cheaper" concept. As technology advanced, computers could do many things that once required an astronaut. Since computers don't need to breathe or be kept warm, focusing on unmanned probes allowed NASA to run "high risk" missions where it would never be permitted to risk a human. The simple fact that probes do not necessarily need to return to Earth also simplified the process immensely. In the late 1960s as the Apollo program was winding down, an astronomer at NASA's Jet Propulsion Laboratory realized that an alignment of Jupiter, Saturn, Uranus, and Neptune would occur in the late 1970s which would enable a spacecraft to travel to all of them using only a small amount of fuel (Weaver, 1970). Although this "Grand Tour" was one of the many NASA programs cut in the post-Apollo budget cuts, the dream returned in 1977 when the two Voyager probes were launched to closely inspect the outer planets. Although probes had been used to a small extent during the Apollo program, the Voyager probes were the only unmanned spacecraft to really capture the public imagination, largely due to the fact that Voyager 1 was the first spacecraft to actually leave the solar system. After Voyager, the next probe to really capture public interest by doing excellent scientific work was Mariner 9, which became the first spacecraft to orbit another planet in November of 1971. The most famous Mars crafts, however, have always been the rovers. Only four rovers have ever successfully

functioned on Mars. The rover program began when Mars Pathfinder, also known as *Sojourner*, landed on Mars in 1997. *Sojourner* was the first wave of NASA's "Faster, better, cheaper" concept and it served mainly as proof that unmanned probes could be useful. *Spirit* and *Opportunity*, two twin rovers launched in the summer of 2003, performed remarkably well. *Spirit* continued to operate for almost 6 years and *Opportunity* amazingly is still functional. Considering the original estimates for the longevity of these rovers was about 90 days, the pair has done an astonishing job. Nevertheless, the king of the Mars rovers is certainly *Curiosity*, which landed on August 6, 2012. The Mars rovers, as a whole, have been instrumental in paving the way for human exploration of Mars (Mars, 2012). Numerous other probes have been launched to other areas of interest. The most important of these is the Huygens spacecraft, which is currently humanity's most distant ambassador on Saturn's moon Titan.

The Voyager probes, which were enormously popular by the standards of unmanned space flight, never raised levels of public interest and excitement equal to those of the Apollo or Shuttle programs; unmanned probes simply do not excite the general public in the way manned spaceflight does. Therefore, the advantages of unmanned probes when it comes to science become disadvantages when it comes to politics. Additionally, unmanned probes clearly are not as adaptable as humans. For example, a robot cannot repair spacecraft on the fly like astronauts can and a robot does not have the "vibes" of human astronauts. It simply isn't currently possible to make a robot which can prospect for fossils on the Martian surface. Another issue with

unmanned probes is the light-speed time lag. The distance between probes and NASA command in Houston varies immensely. For example, sending a message to a probe on Mars will have a “time lag” of somewhere between four and twenty minutes, depending on the respective locations of Earth and Mars when the message is sent. This delay can prove very problematic, since it effectively means that every command NASA gives a probe arrives out of date by somewhere between eight and forty minutes (McDougall, 1985). Putting a human on the “Mars end” of this decision loop would immensely simplify the mission and reduce the chance of mission failure. The final serious issue with unmanned spaceflight is that the greater tolerance for mission failure generally leads to more risky missions being undertaken. This tends to increase the failure rate of the program overall, which over time leads to much lower budgets. Perhaps due to these issues and some of the mission failures associated with unmanned spaceflight, public opinion on the future of space exploration is constantly in a state of flux as evidenced by the graph below (Launius, 2003).

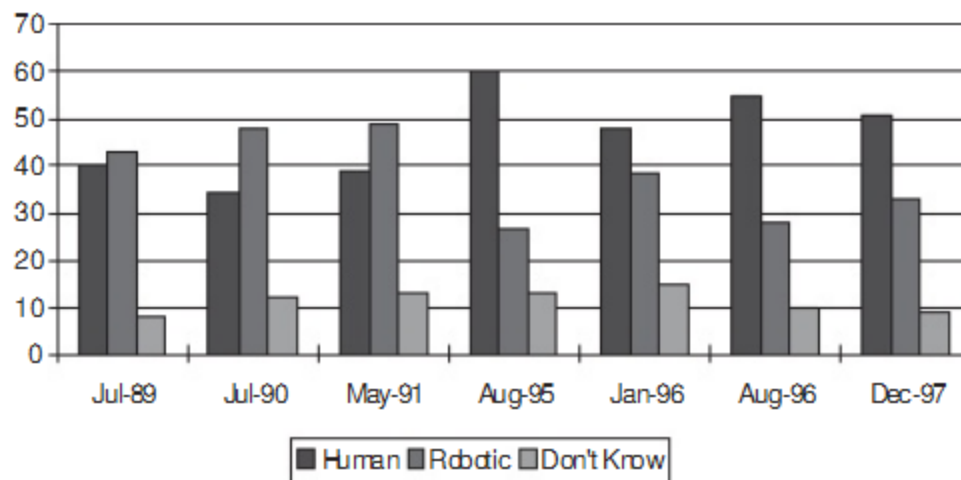


Fig. 9. What should be the primary emphasis of NASA programs.

Graph Courtesy of (Launius, 2003).

Ultimately, the choice between manned or unmanned spaceflight matters far less than the generally successful way unmanned spaceflight gets funded. Since NASA has a bit of a “safety mafia” culture, unmanned flight is seen as a good way to avoid human risk, even if it is generally less effective. When disasters do occur in unmanned flight, they are forgotten much more rapidly than when humans actually die. One example is the infamous \$640 million dollar Mars Climate Orbiter burning up in the Martian atmosphere due to a failure to properly convert units from Imperial to Metric. This allows for more risky missions to be undertaken since mission failure only means the loss of tax dollars, not lives. That fundamental point is almost certainly why NASA and the US Congress are both interested in further funding robotic spaceflight (Zubrin and Wagner, 2011).

### **Part 3: Why NASA Fails**

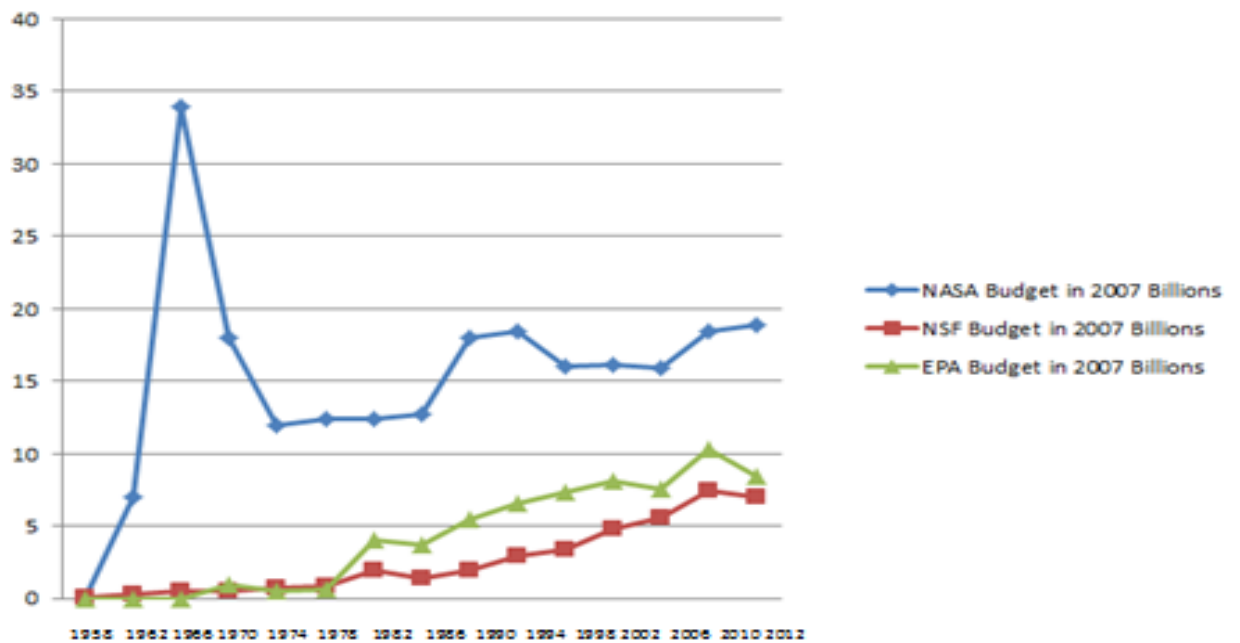
The failures of the early American space efforts, the Space Shuttle, SEI and VSE to maintain full Congressional funding are shockingly contrasted by the success of Apollo and numerous unmanned programs to maintain funding. What is not in dispute is the fact that the NASA budget is not nearly what it was under Apollo or during the time when the USSR had a robust space program (Zubrin and Wagner, 2011). The strength of a President's commitment and the strength of his resistance in Congress are based on many factors: the mission's relative cost, time horizon, level of technical complexity, the ability to sell the program as a defense program, the weakness of the sitting president in spreading his vision to Congress, the exact nature of the decreasing discretionary federal budget due to changing spending priorities like Medicare which lead to less available "free money," the media circus failures of NASA, a lack of public support, the tendency of leaders to "design by committee" which leads to failures, the lack of a "threat" like the Soviet Union, the relative decline in defense spending for which NASA is traditionally seen as an outlet, the failure of NASA to effectively market the manned space flight program due to other priorities, advances in unmanned spaceflight, lack of a clear destination, simple apathy, and finally the fact that many Americans deny that NASA's greatest accomplishment ever occurred.

### **Relative Costs:**

Historically speaking, space programs almost always cost more than their initial estimates. The early US space programs, like Vanguard, were an utter disaster when it came to staying on budget. The first US space program, Vanguard, was originally estimated to cost about 10 million, in 1955 dollars. This estimate rapidly ballooned to 20 million, then 63 million, then 99 million. The final cost on Vanguard was over 110 million in 1955 dollars, over 10 times the original cost estimate (Day, 2004). Both the Space Exploration Initiative and to a lesser extent the Vision for Space Exploration suffered in Congress largely due to the very high costs associated with them. The total cost estimate of SEI was approximately 500 billion in 1990 dollars spread over 20 to 30 years (Dick, 2008). These projections were an easy point of attack for every member of Congress who opposed either program. VSE survived slightly longer because it was projected to cost a “mere” 271 billion in 2002 dollars, which was significantly cheaper than SEI (Day, 2004). In contrast, when it came to producing results, Apollo was king. The relatively low cost of the Apollo program, even when the prerequisite Gemini and Mercury missions are factored in, contributed greatly to its success in running the budgetary gauntlet that is the United States Congress. If all three missions are compared, clearly the cheaper missions were more successful or at least lasted longer than more expensive missions. If going through each appropriations cycle is analogous to playing Russian roulette, reducing the estimated cost of the program is the equivalent to reducing the number of bullets in the gun. Hence, cheaper space programs are inherently more politically viable and more likely to attract Congressional approval

votes. However, the Moon mission was very expensive since it included the Gemini, Mercury, and Apollo programs. The Apollo program would cost about 109 billion dollars in 2010 dollars; while Gemini and Mercury would cost 7.4 and 1.6 billion respectively in 2010 dollars. However, these amounts were still a larger portion of the total level of federal spending than NASA's portion today. The high point of NASA spending peaked during Apollo at roughly 4.4% of the federal budget. The level of spending earmarked for NASA dropped below 1% of federal spending in 1970 and is currently hovering around 0.7% of total federal spending (Lafleur, 2010). As demonstrated by the graph below, even when inflation is adjusted using the GDP deflator, the NASA budget has been relatively constant since the end of the Apollo era while other science agencies like the EPA and the NSF have had their budgets dramatically increase. The graph also shows just how restricted the total level of funding is for NASA in the post-Apollo era.





Year	NASA Budget in 2007 Billions	NSF Budget in 2007 Billions	EPA Budget in 2007 Billions
1958	0.1	0.1	0
1962	7	0.3	0
1966	34	0.5	0
1970	18	0.5	1
1974	12	0.7	0.5
1978	12.4	0.9	0.6
1982	12.4	2	4
1986	12.7	1.4	3.7
1990	18	2	5.5
1994	18.5	3	6.6
1998	16	3.4	7.4
2002	16.1	4.8	8.1
2006	15.9	5.6	7.6
2010	18.4	7.5	10.3
2012	18.9	7	8.4

With this current focus on costs and reduced budgets, there has been a great deal of criticism of how NASA spends money internally. Most analysts actually believe that many NASA programs are far more expensive and tap far more of the NASA budget than is needed. For example, the Space Shuttle is widely seen to have raised said costs over the originally expendable launchers of the Apollo Era (Jurist, Dinkin, and Livingston, 2005). The Russian Energia rocket averaged a cost of \$110 million per launch; which comes to roughly \$1,900 dollars per pound lifted into Low Earth Orbit when design and maintenance are factored (Futron, 2002). The Space Shuttle initially averaged \$110 million per launch; which came to roughly \$5,000 dollar per pound lifted into Low Earth Orbit. However, as the Shuttle fleet aged, that cost ballooned into roughly \$1.5 billion per launch; which came to \$60,000 dollars per pound lifted into Low Earth Orbital (Pielke, 2007). In fact, even the massively overpowered Saturn V, would have been cheaper than the Space Shuttle. In contrast, the more modern Falcon 9 created by the private corporation, SpaceX, costs \$54 million per launch which comes to roughly \$1,800 dollars per pound lifted into Low Earth Orbit (Follett, 2012). All costs previously listed have been adjusted for inflation via the GDP deflator to be in 2007 dollars.

But overpriced launch vehicles aren't the only way NASA has squandered money. The changing priorities of NASA, which will be discussed in a later section, have reduced the total amount of NASA's available funding.

### **Mission Time Horizon:**

If reducing program cost is equal to reducing the number of bullets, then shortening the mission timeframe is the political equivalent of reducing the number of rounds of Russian roulette. The projected timeframe is another important factor to be considered when designing a mission which can pass through the appropriations process. Presidents have an immense political incentive to structure mission time horizons so the majority of the actual spending falls on their successor. The importance of Presidential leadership in space exploration cannot be overstated; however, the initial support of a sitting president often isn't enough to get the job done. The very nature of space exploration requires long periods of investment in both money and time. However, during any administration's allotted timeframe; very little visible progress occurs during its four to eight year term. However, when visible progress begins, it is incredibly dramatic. Politically, this means that a presidential administration runs the very real risk of spending large amounts of political capital to maintain an exploration program, and then see the next administration come in to either eliminate the program in a round of budget cuts or take credit for it. From the perspective of even an eight year administration, space exploration is a high risk/ low reward activity in a political sense. This theoretically would lead to the first President and his party getting the credit for the concept while the successive President carries the financial burden of continuing a program which isn't his own. Furthermore, historically, new presidents,

particularly if they are not from the same political party, frequently target previous space programs for budgetary cuts. Nixon cut Kennedy's Apollo program, Clinton ended Bush Senior's Space Exploration Initiative, and Obama ended Bush Junior's Vision for Space Exploration. Essentially this effectively imposes a "cap" of approximately 10 years on any given mission time horizon. The longer the time horizon, the less likely the mission is to pass the hurdles of the next appropriations process, due largely to the sunk cost, or the fact that the money has already been spent. The Space Exploration Initiative was particularly infamous for the long time horizon proposed for program development. SEI had a 30 year time frame, featuring a gradual build-up of space infrastructure by building massive space stations and moon bases. This required continued Congressional approval under multiple administrations. Additionally, SEI spending was structured so spending would fall disproportionately on the next administration. This long time horizon increased opportunities for Congress to deny SEI the appropriations it required to succeed. To have the best chance of success, a President should ideally frontload the spending to occur during his term. However, the exact opposite problem occurred in the Space Exploration Initiative. Despite the manipulations of the Maryland Senator which denied many appropriations, some spending on SEI was approved (Report, 1989). However, SEI was structured so most spending would fall under the next administration even if Bush had been reelected. Bush probably structured the program in this way to avoid criticism from deficit-reduction groups gaining influence at the time. Yet presumably, a new administration would have no political interest and thus little

motivation to continue funding a program which they did not start (Zubrin and Wagner, 2011).

However, VSE's 16 year timescale was shorter than SEI's; thus the program got further. The major issue for both programs was that a new Congress was elected before either could achieve highly visible successes (Zubrin and Wagner, 2011). Essentially, these programs were structured so all technologies needing development would exist before any flights were actually launched. This makes sense from a research perspective, but makes programs vulnerable to cancellation as Congress or a new President can effectively claim they didn't accomplish anything. Apollo, on the other hand, was organized in a remarkably short time horizon with most of its technology developed as needed (Benson, 1978). The surprisingly short development of the Mercury and Gemini programs paved the way for the use of the Saturn V rockets to become the Apollo program. The total time horizon from the start of the program to the voyage of Apollo 11 was only about 8 years, which is far shorter than either SEI or VSE. Additionally, Apollo was structured to create immediate results with the Mercury and Gemini programs. These programs created political cover for Apollo as it would be far more difficult to cancel a program after it has been publically seen to produce results (Zubrin and Wagner, 2011). Even though Apollo endured several public relations and technical disasters, like the fire which killed the Apollo 1 astronauts, the political cover offered by earlier successes offset the failures, which led to public support climbing dramatically. NASA's success bred more success and, most importantly, increased public and Congressional support. This cycle of victory culminated in what many consider the

greatest achievement of humanity, the successful landing of Apollo 11 on the Moon.

The Apollo program continued Moon exploration over the course of several other missions until 1972 (Benson, 1978). However, in 1968 another political party came into office and immediately altered the previous administration's space policy. This new administration virtually scrapped the Apollo program, letting billions of dollars of rockets sit on the lawn at the Kennedy Space Center. The envisioned follow-up missions never materialized as plans for Low Earth Orbit Missions in the Space Shuttle trumped the Saturn Vs (Ragsdale, 1997.) Overall, NASA seems to have a strong preference for lengthy multi-year programs structured to provide lengthy periods of testing, research, and technological development. Unfortunately, this approach often conflicts with political goals and timelines.

## **Right Way, Wrong Way, NASA Way- Internal NASA Politics as Applied to Technical**

### **Issues:**

Another major political hurdle to a successful Mars mission is the technical challenge of space flight. Overly complex missions are more difficult to explain to Congress and more difficult to achieve, but they tend to be more popular with NASA since they increase the number of scientists and engineers needed. Since the late 1960s, NASA, like all federal agencies, has increasingly been run by bureaucrats. This causes “mission creep,” which leads to technologies being considered “mission critical” to appease internal stakeholder groups in NASA who want their technology of choice to get funded (Zubrin and Wagner, 2011). This same mission creep encourages programs to have higher budgets and run over longer periods of time, resulting in increased job security for NASA employees. Yet at the same time, it hinders the program’s ability to pass through the Congressional appropriations process. An example of this phenomenon can be found in the 90-Day Study of the Space Exploration Initiative. A large part of VSE’s incredibly high budget came from the way the mission was structured.

To understand exactly why VSE had a high budget, one must understand something about the way Earth and Mars orbit one another. In 1925 German mathematician Walther Hohmann discovered a “Hohmann transfer,” which uses only the gravitational energy of the Earth and Mars for thrust. This orbit takes 258 days to complete unpowered. If extra propellant is used to accelerate and decelerate, a craft could reach Mars in 180 days (Hohmann, 1925). When the crew arrives on Mars, it

essentially would face two choices. The first choice, or conjunction mission, would be to remain on site for no less than 550 days until Mars reached the same approximate position it had when the astronauts left Earth. Using this conjunction mission, the astronauts could use the same orbit used to get to Mars to return to Earth. The total mission time for a conjunction mission would be about 910 days, with most of that time spent, around 500 days, waiting on Mars for the right launch conditions. The second choice, or an opposition mission, requires that the crew must return almost immediately with a maximum allowable stay time of about 30 days. The return trip, however, would take about 430 days because it would necessitate using the gravity of Venus to slow down enough to avoid missing Earth. This mission was favored by both the Space Exploration Initiative and Vision for Space Exploration allegedly because it minimized the total mission time with a comparatively short 640 day mission time. Traditionally, short missions are better because they limit exposure to zero-gravity and space radiation. However, an opposition mission actually increases the average mission radiation dose from 52 rem to 58 rem as it necessitates the “Venus Fly-by” which dramatically increases the crew’s radiation dose due to Venus’s proximity to the sun. Essentially, flying to Mars when it is at conjunction reduces both zero-gravity and radiation exposure (Zubrin and Wagner, 2011).

So SEI decided on opposition missions, yet that decision ultimately would doom the project. It turns out that the only propulsion system powerful enough to meet the braking requirements of an opposition mission would a Nuclear Thermal Rocket or NTR. NASA administrator Richard Truly, who served under President H.W. Bush, was an



advocate of NTR technologies and many of the NASA centers were working on NTR programs at that time. To create a demand for a NTR, the scientists who wrote the 90 day report suggested a mission design with requirements only a NTR could fulfill. To be fair, NTRs do have the enormous advantages of power and fuel efficiency (Dewar and Bussard, 2009). Yet, despite these advantages, NTRs contain the word “nuclear,” which virtually guarantees a difficult passage through the Congressional appropriations process, since a proposed launch of any such vehicle would almost certainly be fiercely opposed by the anti-nuclear lobby. Nuclear rocketry still holds great promise but any potential nuclear rocket would have to deal with the forces that killed the original program, Nuclear Engine for Rocket Vehicle Application (NERVA). NERVA was shut down in 1972, but it actually built more than 20 nuclear thermal rockets which were confirmed by NASA’s Space Nuclear Propulsion Office to meet the mission requirements for a Mars mission. However, the program was cut when the Nixon administration slashed NASA funding despite the validity of the idea and the existence of functioning rockets. Amazingly, 2 of these rockets still exist and are sitting in a government warehouse (Bowles, 2004).

Internal forces in NASA, ignoring the inherent political difficulties, continuously pushed for the development of NTRs and VASMIR thrusters which would necessitate the use of nuclear reactors in space (Dewar and Bussard, 2009). However, requiring an opposition mission wasn’t the only overly complex bit of mission architecture in the SEI. Historically most successful NASA missions, like Mariner, Viking, and Apollo, were done by direct launch from the ground into low-Earth orbit; then they used another stage to

throw the craft onto its trajectory. No successful mission beyond low-Earth orbit has ever been assembled in orbit or on the Moon. One of Senator Mikuski's key objections to SEI was the necessity of orbital assembly. Senator Mikuski still holds an important position on the Appropriations Committee, and could easily block future missions which necessitate orbital assembly (Zubrin and Wagner, 2011).

Furthermore, the Space Exploration Initiative's complex proposal required its huge "Battlestar Galactica" spacecraft to have massive aeroshields for aerobraking in the Martian atmosphere. The required size of these shields necessitated orbital assembly, which in turn necessitated a space platform to perform the assembly. This led to the design of the massive Space Station *Freedom* whose initial purpose would be to manufacture a spacecraft for the Mars mission. However, the buildup of space infrastructure represented by Space Station *Freedom* would prove remarkably expensive and enormously complex, which impaired its passage through Congress. It could have simply been replaced by a simpler direct launch from Earth (Ragsdale, 1997). Overall, SEI was tailor-made to be overly complex and occur over a long timeline to gain support from the various bureaucratic divisions within NASA (Ragsdale, 1997). The issues of expense, long-time horizons, and technical complexity that made it appealing to constituencies within NASA made it utterly opposed by Congress. This caused SEI to die a quick death in the appropriations process.

Compared to SEI, VSE was far simpler in a technical sense. However, it was still more complex than any NASA project fully funded to completion by Congress. A central

idea behind VSE was the lunar centric mission architecture. Essentially, this plan would attempt lunar landings under the justification that the Moon would be used as a refueling, servicing, and refitting port for Mars-bound space flights which would necessitate orbital assembly, and thus it ran into the previously mentioned problems (Humphries, 2006). Although it is true that the lower gravity and virtually nonexistent atmosphere of the Moon would make it easier to construct and launch rockets to Mars, a VSE style lunar refueling base has serious problems due to the gravity of the Earth-Moon system. A spacecraft which plans to refuel on the Moon actually requires a more powerful rocket than a spacecraft in a Hohmann orbit to Mars. This is because it is possible to use the thin atmosphere of Mars to slow the spacecraft, allowing it to save fuel which would need to be used to decelerate. However, the Moon has no meaningful atmosphere, which means the ship must spend large amounts of fuel to escape the Earth's gravitational field, and then spend even more fuel to slow down enough to avoid crashing into the Moon. From the standpoint of propulsion, it is far easier to go from low Earth orbit to Mars than it is to go from low Earth orbit to the Moon. Once scientists add in the massive costs of constructing a base and mastering the technologies of converting lunar regolith into rocket fuel, the entire scenario becomes a logistical and financial nightmare which Congress would simply refuse to fund (Zubrin and Wagner, 2011). In addition, powering such a base via solar power would be difficult due to the Moon's 28 day light-dark cycle. This means the only viable choice for the power system of a lunar base would be a nuclear reactor which, as previously discussed, would create a tremendous backlash from anti-nuclear groups and greatly complicate the passage of

appropriations in Congress. In fact, Congressman Dave Weldon (Republican- Florida) who was a well-known supporter of VSE and originally stated VSE was “the best thing to happen to the space program in decades,” strongly opposed the lunar refueling base because he recognized that it would cause future Congresses to cancel the entire program. In summary, VSE was less complex in a technical sense than SEI, but was still a political nightmare.

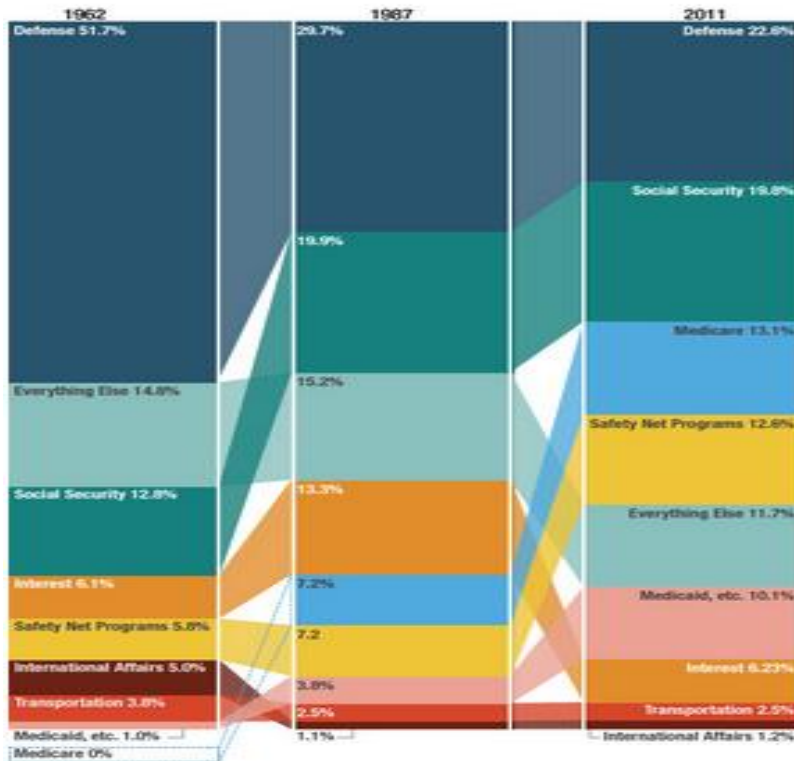
If SEI and VSE are textbook examples of why governments simply don’t understand how to reduce the technical complexity of space exploration, Apollo is their antithesis. The entire program and all preceding programs were run specifically to reduce the technical difficulties. These programs used direct launches to eliminate the need for assembly in low-Earth orbit. The truly massive Saturn family of rockets was created to lift the large payloads needed. A lunar orbit rendezvous was chosen which simplified the entire equation by reducing the tangible mass which would actually be landing on the Moon. The entire program was remarkably simple and robust. In one particular Apollo mission, an oxygen tank exploded but, thanks to the remarkable redundancy inherent in the Apollo design, the crew returned safely to Earth after making makeshift repairs. This prevented a political disaster which would have almost certainly cost the program its remaining funding and destroyed the credibility of NASA and the Congress that funded such a mission (Drushel, 1970). Future missions to Mars need to have that level of reliability to be politically feasible.

### **Sold as Defense Program:**

Largely due to the increasing burden placed upon the budget by entitlements, which will be discussed in another section, the defense budget has drastically shrunk as a proportion of total federal spending. The defense budget often mirrors the NASA budget due to the high levels of cooperation between the two agencies. Since NASA is funded out of federal discretionary spending, space programs passing through Congress are often “sold” as either defense or education “tie-ins” (McDougall, 1985). This was particularly evident in the design of the Space Shuttle in which the Department of Defense had a tremendous amount of input. Both defense and education spending by the federal government are considered to be “discretionary” spending which is presently declining as a proportion of the overall budget, due to the expansion of entitlements. Historically speaking, spending on both defense and education increases dramatically when a clear and present threat to the nation exists. However, these “Sputnik moments” are rare, as detailed earlier. Although Sputnik was instrumental in temporarily boosting the funding of NASA to create the Apollo program, such an event cannot be counted on to boost funding in the foreseeable future. The only thing that could be counted on to dramatically increase the funding of NASA over the short term would be a serious issue which required specialized skills to solve, such as the detection of an asteroid set to collide with the Earth, a conclusive discovery of extraterrestrial life, strong evidence of extraterrestrial intelligence, the rise of a new “Space Race,” or a sudden grassroots swell in support for space exploration. Essentially, NASA cannot count on a “Sputnik moment” to save it from budgetary cutbacks since there doesn’t

seem to be any serious challenge to American space superiority or military dominance at the moment. This simple fact has led to the defense budget's radical reduction as a proportion of the total budget, which ripples over to agencies associated with the Department of Defense like NASA.

The graph below indicates that defense spending as a proportion of total spending shrunk from 51.2% just before the start of the Apollo program in 1962. As of 2011 total spending is around 22.6% Total discretionary spending is also down, due to the increases in entitlement spending. The exact same pattern is evident in education spending too (Vo, 2012).



Graph courtesy of (Vo, 2012).

This relative decline in defense and education spending as a proportion of the budget is mostly explained by the relative decline in total discretionary spending recently. Simply put, there is less “free money” around for discretionary programs despite the total size of the federal budget being much larger. Since the total “pot” of discretionary spending is relatively smaller than it once was, various agencies of the federal government aggressively fight each other for portions of the federal budget. This means that the agencies of government which get the biggest shares of the federal budget in one year are likely to get the biggest share in succeeding years; essentially, it is very difficult for any independent agency to increase its funding drastically in the current environment unless political considerations change. Additionally, since NASA has a reputation for repeatedly going over initial cost projections, Congress is generally reluctant to put large amounts of money into it. This happens because Congress has been repeatedly “burned” in the past by massive cost overruns in the International Space Station, the Hubble Space Telescope, and the Space Shuttle programs. Unfortunately for NASA, the political considerations rarely change in its favor due to reasons which will be discussed in other sections.



### **Power of President in the Congress:**

In his 1962 speech, Kennedy very publically declared “we choose to go to the Moon.” Kennedy also had the very real advantage of Democratic majorities in both Houses of Congress and a Vice President who acted as a skilled whip. The ability of the president to advocate for continued expansion of extraterrestrial exploration requires him to effectively wield the power of the “bully pulpit” to push his agenda through Congress. However, the political fight of getting appropriations bills passed and maintaining funding levels is always intense since the political boost of successful space exploration typically occurs well after the program is completed in successive administrations. Even after the Apollo landings, only 53% of Americans believed that the historic event justified costs. While the Apollo program was actually taking place, most Americans opposed funding trips to the Moon at taxpayer expense (Newport, 1999). Today, many citizens still bitterly oppose space exploration. This institutionalized opposition shows the massive policy hurdles which must be overcome to fund space exploration.

During H.W. Bush’s Space Exploration Initiative, public support for exploration was about where it had been during the Apollo program. After the announcement of SEI on the Smithsonian steps, a dramatic upswing in public support was born; then problems occurred. Over Bush’s term, Congress was held by strong Democratic majorities (Composition, 2012.) This posed an obvious problem for SEI, since Democrats saw the political vulnerabilities as excellent excuses to oppose the President. Failure to

pass SEI appropriations would make H.W. Bush look weak, and with the 1992 Presidential elections looming, Democrats targeted these appropriations. When Bush saw the conflict, he realized he couldn't pass the massive appropriations SEI required without destroying his political capital. The program, already burdened by massive cost estimates and a long time scale, was doomed to crash and burn without the support of the President or a majority in Congress (Zubrin and Wagner, 2011).

Later, public support was moderately high for G.W. Bush's Vision for Space Exploration since the policy announcement closely followed the Columbia disaster. VSE was seen as a way to get public support for space exploration again by providing NASA with a clear goal. VSE called for the space program to complete the International Space Station in 2010 which would herald the retirement of the Space Shuttle. This would be replaced by the Orion by 2008, which would begin conducting missions in 2014. Along the way, the Moon and Mars would be explored by robotic missions. Finally, the landing dates were targeted for the Moon by 2020 and Mars by 2025 (The Vision, 2004). G.W. Bush's VSE had an advantage over SEI in the appropriations process; both Houses of Congress were under Republican control (Composition, 2012). However, a potentially fatal reelection battle loomed in Bush's future as did the escalating conflict in Iraq which combined to prevent the President from committing to VSE. After the election victory in 2004, things looked fairly solid for the Republican Party which picked up seats in both Houses of Congress and controlled the Presidency. The majority of the spending and the greater part of technological development for the missions were largely completed during the period of nearly continuous funding from 2004-2006. However, this wasn't to

last. The 2006 elections were a disaster for the Republicans, with Democrats seizing control of both the House and Senate with a substantial majority in the House (Winger, 2007). This immediately brought all new VSE appropriations to a grinding halt, forcing the administration to cancel the Mars portion of VSE. However, many initial programs were already financed and continued to function. The largest was the Constellation Program which was producing the launch vehicles for Moon missions. These programs didn't come up for renewal until 2009, so they survived. Nevertheless, the 2008 election of the Obama administration signaled the death knell for Constellation. Despite the fact that most of the program funds had already been spent developing Orion and the Ares boosters, President Obama inexplicably cancelled the program for reasons not entirely clear. Obama's space policy shifted attention towards the ISS and the goal of landing on an NEA (Near Earth Asteroid) by 2025. This required development of a new heavy launch system which could have easily been an adapted Ares rocket booster (Zubrin and Wagner, 2011). The destructive and crippling irrationality of opposing political parties towards each other's space policies is a recurring theme in NASA funding.

Although Obama may be the most recent President to cancel successful space programs with little justification, he is by no means the first. Nixon's destruction of the Apollo program is directly responsible for the general malaise that permeated the space community from the mid-1970s onward. When Nixon was inaugurated in 1969, the near completion of the Apollo program made it difficult to cancel for purely political reasons. The high profile nature of the program, coupled with Kennedy's call for the moon mission with obvious Cold-War benefits, also helped lend the program a nearly

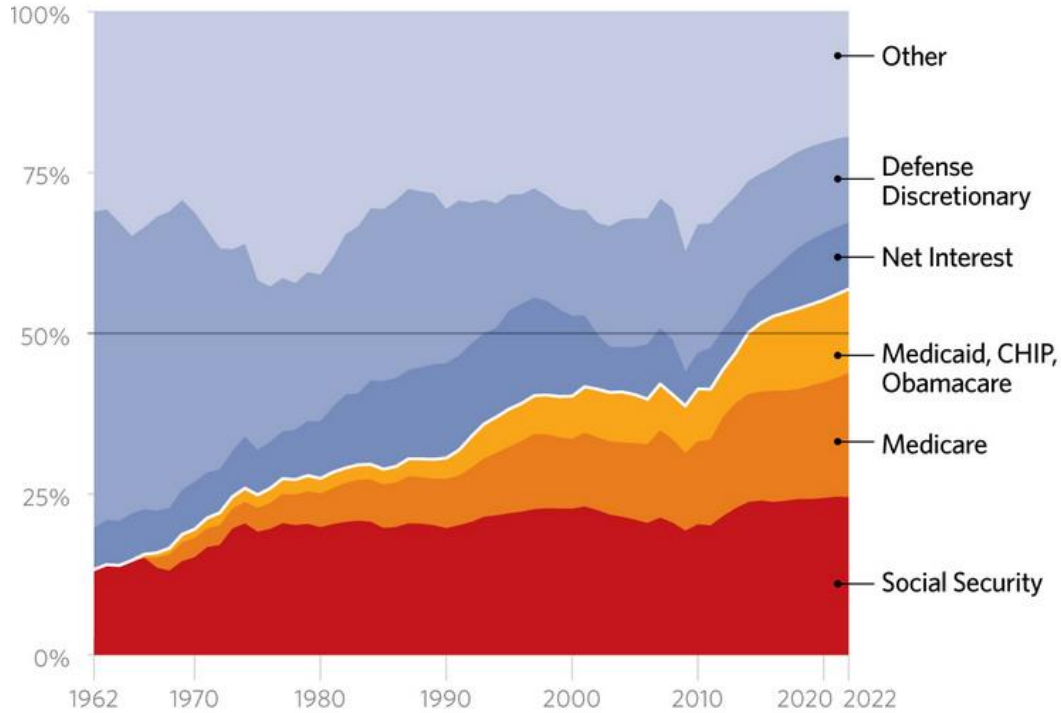
invincible shield, at least until the moon landing was accomplished. Nixon's cancellation of the follow-up missions after Apollo 17 paved the way for an increasing focus on cost-cutting in space exploration which focused on doing scientific research via Skylab. This idea culminated in the concept of a reusable launch plane which ultimately led to the Space Shuttle. Ultimately Nixon's ideas led to a retreat from the Moon and a return to low-Earth orbit. The success of Apollo in the political arena is largely contingent on the fact that the program's greatest achievements didn't occur under the president or party who started it. Yet Kennedy and Johnson still received most of the credit even though the results occurred under Nixon. However, in those 8 years of Apollo development, the composition of Congress didn't change significantly. The Democrats maintained solid majorities in both Houses and held onto the White House while most of the research and development to support the Apollo program was done (Composition, 2012). The overall message is clear: new Congressional and new Presidential administrations, specifically those of a different political party, have a tendency to be hostile to "the old way" of space exploration and demonstrate a marked propensity to cancel each other's programs. This seems to occur even when such cancellations prove harmful to their own interests. Thus, the best situation possible for a successful "Mars shot" would be stable administration headed by a president strongly committed to the program with large majorities in both Houses of Congress to provide funding over an extended period of time. Historically speaking, this is remarkably uncommon. NASA might as well ask for Mars to come to it.

### **Decreasing Federal Discretionary Spending:**


Presently, federal spending is divided into discretionary spending, mandatory spending, and net interest payments. Discretionary spending is expenditure that is determined directly by Congress and therefore must be continually reauthorized. Mandatory spending is defined as expenditure other than that determined by Congressional appropriations and occurs without Congressional authorization. The majority of mandatory spending is entitlement programs such as Social Security and Medicare which are by far the most expensive federal programs (Austin and Levit, 2012). These programs create massive increases, and even more massive projected increases in entitlement spending, particularly for Social Security, Medicare, Medicaid, and insurance exchanges under the Affordable Care Act (Aka: Obamacare). Fifty years ago Medicare and Medicaid, which combined now make up a quarter of federal spending, did not exist (History, 2012). Other governmental programs, particularly the safety net programs and Social Security have grown exponentially since the founding of NASA. These built-in mandatory expenses will ultimately result in discretionary spending continually decreasing as a proportion of the federal budget (Austin and Levit, 2012).

## Entitlements and Interest Are Crowding Out Other Spending

SHARE OF TOTAL OUTLAYS

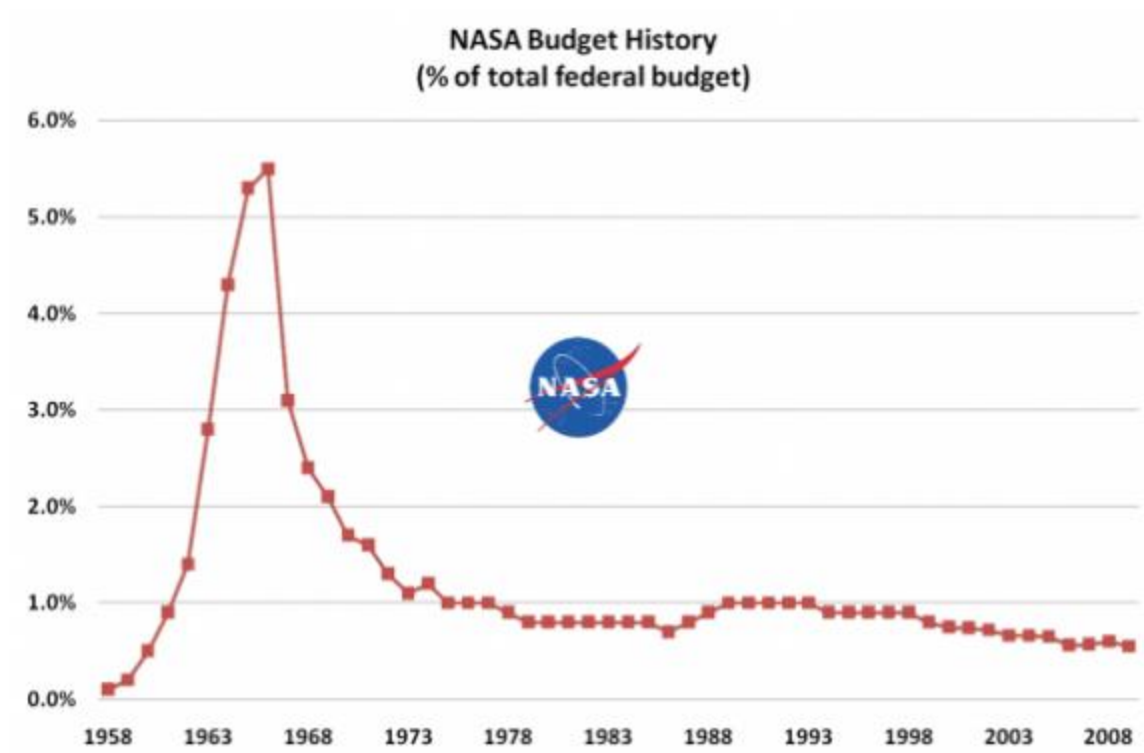


**Sources:** Congressional Budget Office, *An Update to the Economic and Budget Outlook: Fiscal Years 2012 to 2022*, Table 1-1, <http://cbo.gov/publication/43543> (accessed August 23, 2012), and Office of Management and Budget, *Budget of the U.S. Government, FY 2013: Historical Tables*, Table 8.5, February 2012, <http://www.whitehouse.gov/omb/budget/Historicals> (accessed August 8, 2012).

Federal Spending by the Numbers 2012  heritage.org

Graph Courtesy of (Budget, 2012).

As the graph above shows, mandatory spending, which includes Medicare, Medicaid, Children's Health Insurance Program, Obamacare, Social Security, and interest on the National Debt, make up roughly 60% of the federal budget and these programs are predicted to grow rapidly in the near future (Budget, 2012). Healthcare spending, particularly Medicare, Medicaid, and the expenditure for insurance exchanges under Obamacare are expected to continue ballooning unless dramatic action is taken by Congress (Austin and Levit, 2012).





As shown above, this increase spending on healthcare has a “crowding out effect” which will ultimately lead to less money for peripheral federal agencies, like NASA, whose benefits are not easy to see to the average taxpayer. Since cutting entitlement spending is something of a “third rail” in politics, and the national deficit is on the verge of getting truly out of hand, it is very likely that the serious cuts which will eventually be necessary will be made to discretionary programs like NASA.

### **Highly Publicized Failures of NASA:**

The average Presidential administration cares little for space policy, but when NASA makes a mistake, especially an inept one, it can be absolutely devastating politically. Therefore, most Presidents and Congresses tend to base their space policy around avoiding mission failures. This has the slight side effect of basically forcing NASA not to do anything which risks human lives. This “safety mafia” doesn’t really apply to robotic missions, however, so these have quickly become the mission style of choice. However, modern robotic mission have a much higher rate of failure than manned missions for the simple reason that they are virtually impossible, or prohibitively expensive, to fix if something goes wrong. In modern times, NASA has been plagued by numerous technological failures which in turn led to massive cost overruns and a lack of return on the initial investment. Many of these craft failed due to “incompetent mistakes,” which destroys the prestige of the agency and damages its ability to request new funding.

The Genesis spacecraft was an excellent example of a NASA mission whose complicated technological details functioned almost perfectly, only to have the \$264 million dollar mission end in failure due to a problem with the parachute (Genesis, 2005). Another devastating event was the explosion on launch of the \$424 million dollar Glory satellite which was supposed to simply measure data for climate scientists (Harwood, 2011). Yet another disastrous mission failure was the extremely embarrassing and very expensive \$640 million dollar Mars Climate Orbiter. This mission failed due to an incredibly inconceivable mistake which occurred because the fight

system software on the orbiter was calibrated to use the metric unit, newtons, while the ground software was calibrated to the Imperial unit, pound force. The difference between the two units was sufficient to cause the Orbiter to enter the atmosphere at a lower than desired altitude, which led to the craft burning up in the Martian atmosphere (MCOMIB, 1999). The other remarkably absurd mistake occurred during the manufacture of the weather satellite NOAA-19. Essentially the very expensive satellite was badly damaged because a Lockheed Martin technician accidentally knocked it onto the floor. Repairs to fix this extraordinarily foolish error ended up costing \$135 million dollars, some of which was paid for by Lockheed Martin (Bates, 2004). By far the most devastating mistakes, however, are those which infringe upon the credibility of NASA's astronaut corp. The infamous "Apollo 15 Postage Stamp" incident and the Lisa Nowak "Astronaut" sex scandal seriously undermined Congress' faith in NASA. This was made much worse by the fact that Congressmen and citizens could clearly identify the actions of the astronauts as immoral or crazy. Both the popular press and Congress viciously attacked NASA for these errors (MCOMIB, 1999). Generally speaking, when errors are, by and large, simple and comprehensible to the public and investigating Congressional representative, any incident will seriously damage the credibility of NASA, which consequently undermines public support. Making relatively simple mistakes gives NASA a "bad reputation" among federal agencies and is almost certainly responsible for some of the relative decline in its budget. Stupid mistakes, even if they are relatively inexpensive, are far more damaging to NASA's reputation and thus to its funding mechanisms than expensive, yet more reasonable mistakes.

However, the king of expensive NASA mistakes is certainly the Hubble Space Telescope which ended up costing taxpayers \$10 billion dollars when the multiple repairs required to make it work properly are considered. The Hubble necessitated no less than 5 separate Space Shuttle launches to repair numerous problems including a flawed mirror, failing gyroscopes, and repairs to the telescope's heat sink. The telescope became something of a "white elephant" since it was initially estimated to only cost \$2.5 billion. This goes to show that space programs almost always go over budget and frequently require complex and risky repair missions, which is something Congress hates (Lobbia, 2010). These sort of very expensive and very public mistakes make NASA look careless and incompetent, thus giving Congress an excuse to target the NASA budget.

### **Lack of Public Support Due to Outreach Failures:**

As previously discussed in the history section, public support for NASA has been on the decline in part due to various failures by the agency to appear relevant and to broaden its basis. This has a great deal to do with the culture of the United States, which is obviously directly outside of NASA's control. In the American system, cultural information and preferences are largely passed to the majority of its citizens through movies and television. In recent years, the number and quality of pro-NASA movies and television shows has declined, while the number of anti-NASA or anti-space films and television shows has sharply risen. Even the pro-NASA or pro-space films are rapidly becoming increasingly dark, anti-space, and increasing anti-NASA. Over time, this slowly erodes public support for NASA, which ultimately decreases revenue. NASA's primary means of marketing itself to the average voter, science fiction, was once about how amazing and wonderful the future could be. Scientists, engineers, and technicians grew up reading and watching astonishing gadgets in science fiction like *Star Trek's* non-invasive medical scanners and communicators. They then devoted their lives to science, in part so they could one day discover that fiction could become reality.

Hollywood went from celebrating NASA, space, and human achievement with blockbuster films like *The Right Stuff*, *Star Wars*, *2001 Space Odyssey*, and *Apollo 13* to producing films in which NASA is the villain or technology is demonized as inhuman, like *The Astronaut's Wife*, *Capricorn One*, *Logan's Run*, *Blade Runner*, *2012*, and *Solaris*. A similar metamorphosis occurred in television which went from promoting optimism about the potential of spaceflight through shows like *Star Trek* to creating dark and

brooding shows like *Farscape*, the re-imagined *Battlestar Galactica*, *Falling Skies*, and *V*. Even movies which treat NASA relatively well, like *Deep Impact*, often are immensely pessimistic about the dangers inherent in space for reasons of drama and to add a sense of tension. After all, before NASA can save the world from the asteroid/alien threat, there has to, in fact, be an asteroid/alien threat. Contemporary science fiction is very much focused on apocalyptic and nihilistic scenarios and seems to lack the optimism that inspired the technological advancements of the computer revolution. Over a long period of time, this erodes the public's confidence in space travel and makes the recruitment of top quality staff for NASA much more difficult (Labossiere, 2012).

Despite the obvious benefits of public outreach and marketing, internal forces at NASA see it as the first thing to cut should budget problems occur. At the time of this writing, NASA has prepared to suspend and review all education and outreach efforts as part of a cost cutting effort (Siegal, 2013). NASA should seriously consider following the lead of the American Department of Defense and begin "backing" movies and television shows to improve outreach.

### **The Politics of Designing By Committee:**

President Eisenhower was immensely concerned that the Soviet Union might view a satellite passing above continental Russia as a violation of national sovereignty. Eisenhower was also apprehensive about accusations of being a “warmonger” if former military missiles were used as launch vehicles for satellites. As this was occurring, rivalries between different branches of the American military developed over which branch would have control over future speculated military spaceflight. This political decision led to a long delay in the launch of the first American satellite since it switched the launch vehicle from a Jupiter C military rocket to the untested Vanguard rocket as a political compromise between the service branches of the American military after several very public failures of the military space program (Schefter, 1999). The decision to use Vanguard rockets as launch vehicles and to separate the National Advisory Committee for Aeronautics (the forerunner of today’s National Air and Space Administration) from the military had numerous long term repercussions. The Vanguard rocket being used for political reasons set the standard for the “design by committee” approach NASA began using after the Apollo program.

The final rocket design included many “cost saving” features which actually drove up costs over the long-term. The best example of this was the liquid fuel vs. solid fuel booster debate. If given the choice, NASA would almost certainly have chosen a liquid fuel booster system due to the inherent better performance, lower per-flight costs, lower environmental impact, fewer moving parts, lower long-term maintenance costs,

less developmental risk, and the far safer nature of liquid fuel systems. However, the solid-fuel system was projected by the Office of Management and Budget to have a lower upfront investment, so NASA was forced to select a solid-fuel system (SP-4221, 1984). This exact sort of situation is a running theme repeated numerous times in the design of the Space Shuttle. The Shuttle was “designed by committee” in the worse possible sense of the term, with numerous short-term cost-saving measures leading to a long-term program which was ultimately more expensive. Poor technical choices were made in order to appease various political factions and meet mission constraints which were never intended during the initial design phase. This compromised the low cost nature of the Shuttle Program and ultimately made the entire system far more dangerous than necessary. However, by embracing the “designed by committee” concept, the Space Shuttle Program assured its political fortunes in a way Apollo never had. This concept basically eliminated the internal political disputes inherent in the operations of American government agencies. Since literally every organization in the American government connected with the Shuttle was “on board” in the design phase, the initial “leaky” criticism of the Shuttle was unusually muted for a program of that size. In fact, early criticism of the Shuttle program was virtually nonexistent from either media outlets or internal governmental forces (McDougall, 1985). This, combined with the reflected glory of the Apollo program, caused the Space Shuttle to be far more popular in the public conscious than Apollo ever was, even in hindsight.

However, eventually such accommodations took a disastrous toll. From a purely political standpoint, the Challenger and Columbia disasters were a nightmare for the



prestige of both NASA and the United States. This demonstrates that the political compromise occasionally necessary to get a mission moving may occasionally lead to expensive, destructive, wasteful, and unnecessary mission failure.

### **Presence of External Threat Exemplified by “Sputnik Moments”:**

The United States is presently the clear leader in science and technology in terms of scientific citations and research in the world (Country, 2012). Since the American government tends to invest most in the areas in which it can potentially be surpassed in the near future, “Sputnik moments” result in various competitive scientific races with America attempting to maintain its lead in all fields. However, when no near future challenger is evident or conceivable, very little progress actually occurs (Zubrin and Wagner, 2011). The Space Exploration Initiative, however, lacked a conceivable “villain” which could challenge America in space. At the time, the Soviet Union was withdrawing from Afghanistan and its constituent republics were threatening succession largely due to the reform policies of glasnost and perestroika. The Soviet empire was on the verge of collapsing, so it presented no competitive threat. This caused a perceived lack of need for defense spending, particularly defense spending tied to rocketry which was the traditionally effective view of the space program in terms of research funding. This caused the timing of SEI to be inopportune, to say the least. The Vision for Space Exploration under George Bush Jr. also suffered from the lack of a realistic villain. China’s space program was the only conceivable rival and had only recently lifted its first man into orbit. Most analysts of the Chinese space program had strong doubts about the ability of China to meet their goals on time (Jurist, Dinkin, and Livingston, 2005). Additionally, American rocketry was widely perceived as dominant in the world, providing comparatively little apparent need to advance its ballistic missile capability (Hanks, 1998). Finally, the Apollo program, despite its profound sociological, cultural,

and technological impact was primarily constructed and promoted as a national “Space Race” with the Soviet Union (Sadeh, 2006). The Kennedy Administration was aware that the Soviets had a clear lead in heavy lift capacity; essentially Russia was building large rockets which could lift heavy payloads and were thus capable of achievements like building a space station and orbiting a cosmonaut first. However, the long term trends of scientific and technological development in areas like electronics, computing, life-support systems, precision industry, flight controls, and vectored thrust development were all in America’s favor (Hanks, 1998). After the President committed America to land a man on the Moon, the eventual outcome of the space race was never in any real doubt (Zubrin and Wagner, 2011). However, the program was justified to Congress as a means to catch up to the Soviets in rocketry, which would enable the production of better ballistic missiles thus creating an excuse to sell the space program to Congress as defense spending (Sagan, 1995).

### **An Increase in Other NASA Spending Priorities:**

Recently, NASA has been assigned a variety of new, non-exploration orientated, missions. Expanding the role of NASA diverts resources from the exploration based programs to its massively expanded list of priorities. Essentially, Congress is trying to get NASA to do more, with less, then complaining when this inevitably leads to less progress on every front. It is worth noting that the vast majority of NASA employees believe that this is the reason for the current lack of progress within the agency (Launius, 2012). Congress has been particularly problematic about this when delegating diplomatic, environmental science/satellite management, and educational goals to NASA.

The most eye catching and noticeable example of this phenomenon, largely due to the ease which it could be politicized, was the recent admission by current NASA Administrator Charles Bolden that the agencies “foremost” mission was to improve relations with the Muslim world by highlighting the historic contributions of Islam to astronomy (Garda, 2010). This statement drew immediate criticism for obvious reasons, but it is indicative of the increasingly “diplomatic” role of NASA. Essentially, Congress has started to see NASA as sort of “State Department in Space” whose duty is to other nations through internationally cooperative projects. Historically speaking, international cooperation in space missions is generally a disaster. This is due to issues with the technologies and mission protocols of different nations not being compatible, the possibility of a nation’s early withdrawal from collaborative projects for political reasons beyond the control of NASA and the free rider problem. In addition, NASA has been required to handle numerous diplomatic functions involving the inherent difficulties of

international crews since NASA's primary functions are not diplomatic in nature. The International Space Station is an excellent example of all these processes combining to very badly disrupt a project. A great deal of confusion and expense could be done by eliminating issues with multiple languages in space, making different technologies compatible, and cross training astronauts. If you look at the cost projections, there is actually little reason for NASA to cooperate in space other than to prove that it can. The ISS program was initially projected to cost \$12.2 billion. In the end, the station cost \$150 billion dollars when including the shuttle launches needed to service and crew it. The Russia Federation paid \$12 billion, various European nations contributed \$5 billion, Japan offered \$5 billion, and Canada added on \$2 billion. So essentially, around 84% of the cost of the International Space Station was paid for by American taxpayers and a great deal of this was working out compatibility issues (Lafleur, 2010). NASA is simply not suited for doing the job of the State Department, and attempts to make space agencies perform diplomatic tasks will almost certainly create another costly disaster like the ISS which utterly fails to reach expectations.

### **Lack of a Clear Destination or Goal:**

NASA has clearly lost its purpose, but the problem isn't getting this lack of focus off the front page; the problem is getting NASA back on the front page and into the public consciousness. The only launches NASA does these days are to service the aging International Space Station, which is a textbook case in throwing good money after bad. Low Earth Orbits simply do not grab headlines and funding, in way that Apollo did. Since the Space Station program has been operational for many years now, Americans see it as a case of "been there, done that." While the next "new thing" may be a Mars mission, it is worth noting that a majority of Americans oppose a trip to Mars at taxpayer expense (Zubrin and Wagner, 2011).

Another serious issue is Congress's desire to transform NASA into an environmental/diplomatic version of the National Reconnaissance Office. Essentially, Congress has required NASA to coordinate the launches and data collection from weather satellites for environmental science purposes. This sort of mission has little to do with NASA's primary mission and could probably be better handled by NOAA or another agency primarily focused on environmental science. Blurring the line between the federal agencies in this manner causes a great deal of bureaucratic confusion and has actually led to serious issues involving personnel. Because of these issues, much of the American meteorological satellite fleet has been permitted to age to the point of inoperability by the year 2016. Due to confusion resulting from moving these programs into NASA, the satellites to replace them simply are not ready. NASA has been forced to

do things it simply isn't equipped to do. A similar story occurred in education efforts for the agency.

### **Simple Apathy and Misinformation:**

In the American system the amount of public support a program receives can be a reliable measure of how much money that program will receive. Programs which are popular with highly visible positive results tend to be better funded. Entitlement programs, which now make up the majority of the budget, are remarkably popular since their positive results are decidedly visible. Remarkably, the American public doesn't generally think these entitlement programs are very expensive, perhaps because many actually see their "piece of the pie" in a monthly check. Since attacking a popular program is political suicide and budget cuts have to occur somewhere, politicians tend to target programs which the public believes to be very expensive but which are actually very small portions of the federal budget. Therefore, programs which the general public believes to be very expensive are often quite underfunded. The mentality seems to be that if results and benefits are not immediately seen, they don't appear to exist to the average taxpayer.

This principal can be illustrated by the graph below which shows just how widely misinformed the general public is about how much money the federal government spends on NASA. For comparisons sake, in 1995 the NASA budget was 0.88% of the federal budget, in 1996 it was 0.89%, and in 1997 it was 0.90% (Launius, 2003). After that point, however, the NASA budget declined in relative, not absolute, terms at a constant rate to the 0.53% of the federal budget which it is today.



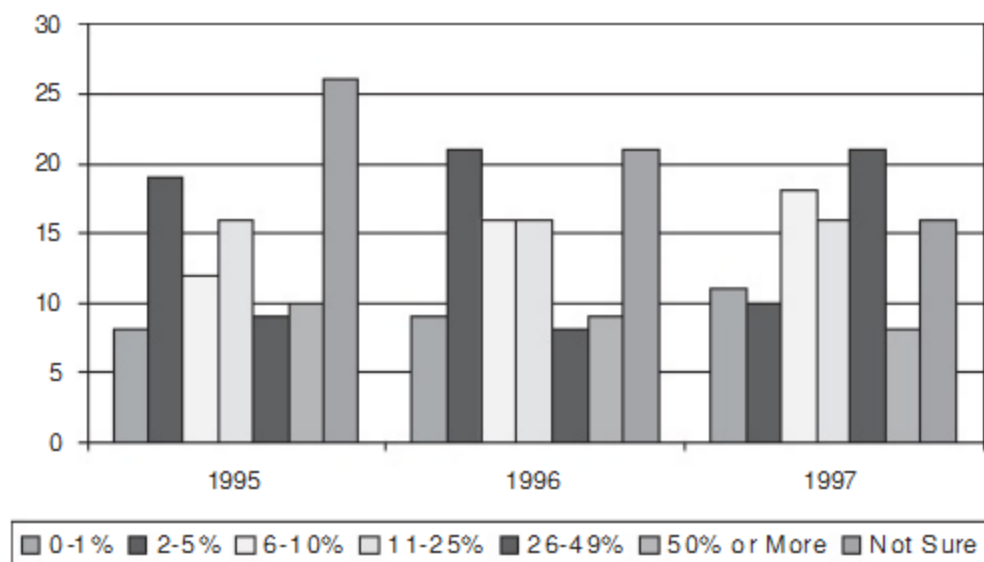


Fig. 15. NASA'S estimated share of the federal budget.

Graph Courtesy of (Launius, 2003)

However, as the graph clearly illustrates, most Americans believe that NASA is a far larger proportion of the federal government than it actually is. Since members of Congress are ultimately responsible to their constituents, this forces NASA to attempt to constantly defend their “budgetary turf” from other agencies. This stiff competition has historically not worked well for NASA, since its budget has been falling as a proportion of the total federal budget since 1991.

## Moon Landing Denial

One of the reasons that NASA has lost so much support, and thus so much funding since its founding is the belief among a strong plurality of Americans that NASA's greatest accomplishment, the Apollo program, simply never occurred. Directly after the Moon landings, roughly 5% of Americans "doubted the moon voyage had taken place." According to a Gallup Poll taken in 1999, 6% of Americans did not believe NASA landed on the moon (Newport, 1999). Estimates into the number of Americans who don't "buy" the "official" story do vary wildly; however, other sources claim that up to 20% of Americans deny the Moon landing. The conspiracy theories got started in the late 1970s after the release of *Capricorn One*, a science fiction movie about a Mars Landing conspiracy (Hyams, 1977). The movie popularized the idea that NASA had never actually landed men on the Moon and breathed life into the previously stagnant conspiracy theories. After the release, numerous books and documentaries were published promoting various lunar conspiracy theories. The modern buzz, which actually dealt a severe blow to the public support for the Vision for Space Exploration, started when Fox television showed a documentary called *Conspiracy Theory: Did We Land on the Moon?* This documentary actively promoted the fringe belief that humans never went to the Moon. Public opinion polls taken in the aftermath of its prime time showing, combined with a general rise in belief in conspiracy theories, indicated that up to 20% of Americans now actively deny the Moon landing (Phillips, 2001). In a 2004 poll, while overall numbers remained about the same, among Americans between 18 and 24 years old "27% expressed doubts that NASA went to the Moon" (Launius, 2010).

In the 2008 and 2012 presidential elections, young Americans voted at remarkably high “wave” rates. This suggests that the “youth vote” is becoming increasingly cynical in politics, so NASA should be very concerned about the high rates of “Apollo skepticism” expressed among young people.

Although all the claims of Moon landing conspiracy theorists have been utterly debunked in their entirety, their enduring presence hinders the ability of NASA to receive funds since many voting taxpayers are convinced that the Apollo landings never occurred. This distrust leads to the public being both less interested in and less inclined to support space exploration (Hyneman and Savage, 2008). Since public funding in the United States is so closely tied to public support, the mere existence of a strong Moon landing denial movement drastically hinders the ability of NASA to receive funding (Launius, 2010). Furthermore, NASA has not really made much of an effort to debunk the conspiracy theories since it apparently believes that addressing the issue would legitimize the conspiracy theorists. Therefore, much of the actual “debunking” of said conspiracy theories has relied on various third party organizations such as academics, science blogs, pro-science community organizations, and most importantly the popular television show *Mythbusters* which did collaborate with NASA during its show on the Moon landings (Hyneman and Savage, 2008). Presently, most of NASA’s public outreach programs are part of the STEM initiative, which stands for Science, Technology, Engineering, and Mathematics, targeted under the 2012 Obama federal budget which was defeated in both Houses of Congress (Fiscal, 2011). NASA’s outreach programs are largely built around museums and educational programs in public schools. However, in

recent years these programs have been redirected towards international outreach. This redirection was coupled by President Obama's NASA administrator, Charles Bolden, stating that one of NASA's primary functions was to "...find a way to reach out to the Muslim world and engage much more with dominantly Muslim nations to help them feel good about their historic contribution to science." The impact of these two redirections in focus has dramatically lowered the perception of NASA among various groups that were once highly supportive (Fox News, 2010). In many ways, the changing focus of NASA, which will be discussed in greater detail in another section, has fed the conspiracy theorists by allowing them to say "if we can't go to the Moon now, we couldn't have gone then." If NASA wants an increased budget sufficient to go to Mars, they should expand their outreach programs and advertise their major accomplishments in a much more effective way. Ironically, increasing the budget and the effectiveness of NASA outreach programs would end up increasing the agency's budget over a long period of time.

## **Conclusions:**

After examining the history of Congressional and presidential support during the appropriations process for major undertakings in the field of space exploration, it is relatively clear how future missions to both the Moon and Mars can be structured to obtain Congressional funding. The most viable way to get a mission funded would be to take every potential measure to reduce the cost estimate of the mission while also shortening its time horizon to be as brief as possible, preferably within a single presidential administration. Additionally, the mission's architecture should be simple, reasonable, and practical, avoiding unnecessary complications like orbital rendezvous or unnecessary bases which do not contribute to the mission. Congress, as a funding mechanism, has a tendency to cancel anything perceived as overly complex, such as both SEI and VSE. Therefore, it must demonstrate visible achievement with measurable short term goals that also support the long term mission. Other facts beyond the control of the mission designers also come into play if the mission is to be funded in a politically survivable way, such as the weakness of a sitting President when it comes to communicating his vision to Congress and the political status of the President's party in Congress. However, internal forces in NASA are directly arrayed against the type of mission which would have the best chance of passing the appropriations process since a low cost, short, simple mission provides comparatively few opportunities to ensure that scientists working for NASA remain employed. NASA should take its own advice: switch over to a "faster, better, cheaper" model for human exploration, just as they did for robotic exploration (McCurdy, 2001). NASA must focus on blending political savvy and

accounting principles with their long-cherished goals of scientific and technological progress. Since learning how to get an appropriations bill through Congress is one of the most vital skills any federal agency can have, such a successful adaptation would make the space program far more effective and viable in the long run. However, increasing the ability of NASA to meet the demands of Congress is only part of the problem. The timing of missions is also a gigantic factor in their success as demonstrated by the testing below.

#### **Part 4: Putting this to the Test**

Rather than simply speculating about how NASA programs have failed in the past, it is far more productive to attempt to quantify the results. This section will essentially put the different theories to the test in a quantifiable way. This will be done by creating a chart of important NASA missions and determining if the mission was a success from a budgetary acquisition standpoint.

This chart is designed to show how optimal the conditions were at any given at the time when the program was conceived. A 1 in any section represents what this writer perceived to be the optimal or near optimal conditions for a successful mission any given category. A 2 in any section represents good conditions for a successful mission. A 3 in any section represents average conditions while a 4 represents bad conditions. The highest ranking, which is 5, is intended to represent disastrously bad conditions from the perspective of getting the launch done. What is considered to be “optimal” in each category is listed below. For clarity, higher numbers are a “worse” score while lower numbers are a better score. Lower scores mean that the mission is more likely to get the “green light” while higher scores are less likely to be approved.



Program and Year	Relative Cost	Long Time Horizon	Technologically Complex	Defense Program	Presidential Control	Discretionary	Recent Failures	Design by Committee	Space Race	Did it Happen?
Orion 1958	5	5	5	1	4	1	1	1	1	2 No
Mercury 1959	3	1	1	1	4	1	1	1	1	1 Yes
NERVA 1961	4	5	5	1	1	1	3	2	1	1 Kinda ended in 1972 *
Apollo 1961	5	2	3	1	1	1	2	1	1	1 Yes, extended dramatically
Gemini 1963	3	1	2	1	1	1	1	1	1	1 Yes
Grand Tour 1968	3	5	2	4	3	1	1	1	1	3 No, delayed to Voyager
Skylab 1973	4	3	3	2	4	1	1	2	2	3 Yes, reduced
Viking 1973	4	2	2	1	4	1	1	2	2	3 Yes
Voyager 1973	1	2	2	4	4	1	1	2	2	3 Yes
Apollo-Soyuz 1975	3	3	5	3	5	2	1	3	3	3 Kinda, reduced a lot
Space Shuttle 1981	4	5	4	3	2	2	2	5	3	3 Yes, extended dramatically
SEI 1989	5	5	5	3	3	3	3	5	5	5 No, killed before anything
ISS 1993	5	5	5	3	3	3	2	5	4	4 Yes, not to original design
Pathfinder 1993	1	1	1	3	2	3	2	2	2	5 Yes
MER Spirit 2000	2	2	2	3	2	4	2	3	3	5 Yes, very successful
VSE 2004	4	4	5	2	2	4	4	5	5	5 No, some flight hardware
Curiosity 2008	2	2	3	2	4	5	3	3	3	5 Yes, very successful

Relative Cost: Optimal is determined to be low cost missions relative to other missions with a similar objective. However, in order to be assigned a 5, the mission must have a large cost in absolute terms as well, since it would cause “sticker shock.”

Long Time Horizon: Optimal is determined to be shorter than 5 years. Each other measurement is graded by the relative difficulty of the project. To be assigned a disastrous rating, the project would need to take more than 20 years.

Technologically Complex: Optimal ranking is determined if the program requires very little or no new technologies to be developed. The higher the number, the more technically complex the problem is.

Defense Program: Optimal ranking requires heavy involvement of military blueprints, personal, funding, technology and lobbying.

Presidential Control: Optimal ranking requires the President to be in control of both Houses of Congress, to publically endorse the program, and to spend political capital supporting the program.

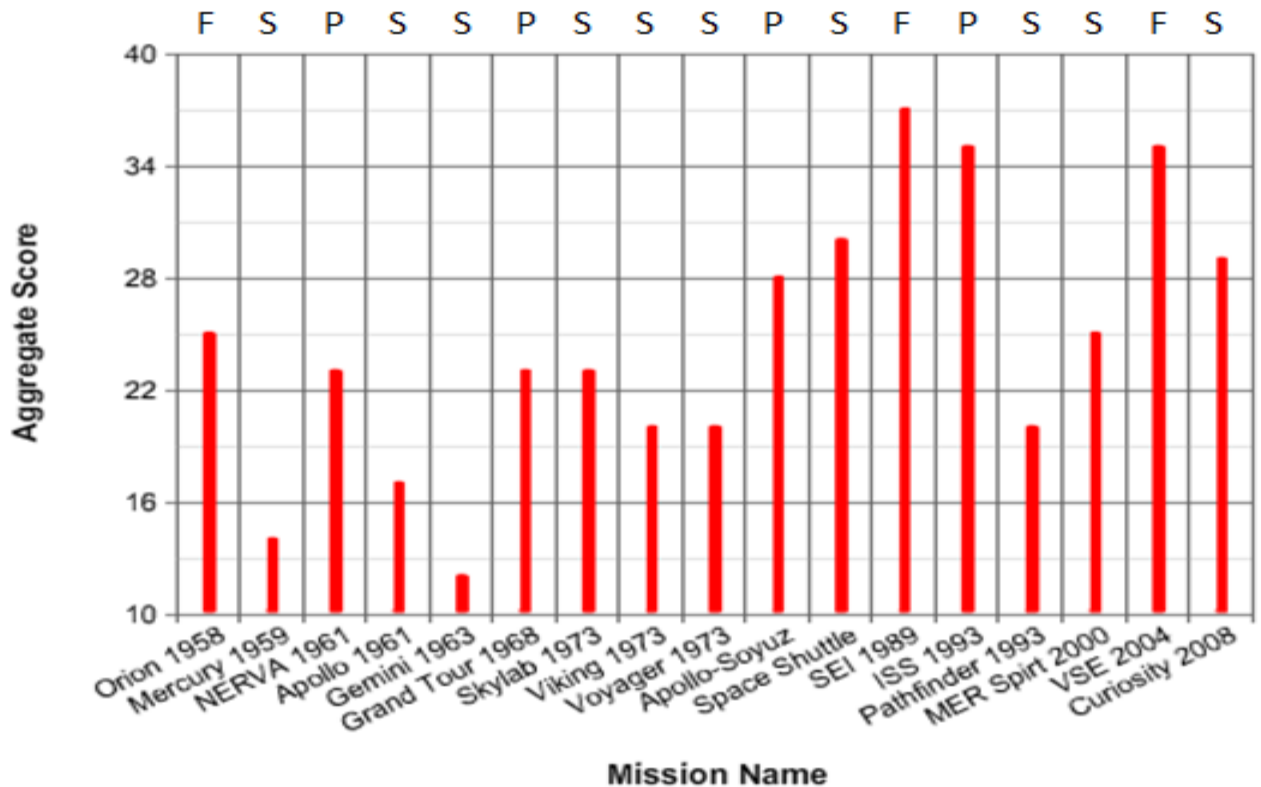
Discretionary Spending as a Proportion of Budget: The optimal ranking only occurs in years during which discretionary spending, including defense, outspends mandatory spending and increased the previous year. Disastrous rankings occur by the percentage discretionary spending is outpaced by mandatory spending.

Recent Failures: Optimal ranking only occurs if there have been no serious “PR causalities” directly before the testing stages. This does not apply to mishaps which occur during the program. Disastrous results are assigned after tragedies like the Challenger explosion.

Design by Committee: Optimal ranking only occurs if the program was created and designed by a single agency while disastrous ratings are only assigned if multiple groups collaborated poorly.

Space Race: Optimal ranking only occurs if the program was conceived during the space race, which for these purposes is defined as lasting from 1955 to 1973. Programs occurring after those dates receive lower rankings.

## Comparison of NASA Missions Based on Success



### The Orion Project: 25/40

The Orion program was an early venture that intended to create a spacecraft powered by the explosion of atomic bombs. This idea was recycled many times, but ultimately evolved into the British Interplanetary Society's Project Daedalus. The program was extremely technically complex and had tremendous costs relative to even Apollo. Daedalus, the final version, which would have been capable of a 50 year journey to Barnard's Star, was estimated to cost around 1 trillion dollars in 1970. This obviously exceeded even the Apollo era budget of NASA. Other issues arose due to both technical complexity and the Partial Test Ban Treaty of 1963. Additionally, President Eisenhower

wanted future spaceflight to be under civilian control, or at least wanted the Soviets to think that it was. A spacecraft powered by atomic bombs would not have reduced Cold War era tensions. Due to these reasons, Project Orion was scrapped in favor of Mercury and Apollo (Summerford, 2012).

### **The Mercury Project: 14/40**

When the space race began, NASA immediately began prioritizing relatively short term missions so as to get “on the board” with the Soviets. This incredibly short timescale, combined with the nature of the Space Race and the relatively low cost of Mercury compared to Project Orion got the program off the ground. The program was also remarkably technically simple and well publicized. Essentially, Mercury has almost certain to receive funding because it was structured in a manner optimally designed to do so and it attempted to do so at a relatively good time. The project was proposed during the Space Race and most of it was executed during the term of President Kennedy, who had a good relationship with Congress. More information about the history of the Mercury project was covered in part 1 of this thesis.

### **NERVA Program: 23/40**

The NERVA (Nuclear Engine for Rocket Vehicle Application) was intended to be used for a visit to Mars by 1978, a permanent lunar base by 1981, and cheap space station resupply. The prototypes were very efficient with specific impulses more than double those of the best chemical rockets available in the present day. However, the time horizon was long, it was very expensive, and most importantly it contained the

word “nuclear” during the height of anti-nuclear hysteria. This program remained on the “backburner” for a considerable length of time and its revival is continuously proposed, but the program, despite obvious advantages, was cancelled in 1972 only to be revived and cancelled again as part of the Vision for Space Exploration.

### **The Apollo Program: 17/40**

Apollo is the golden boy for getting a costly program through Congress. The program was exceptionally expensive and somewhat technically complex, but it had a very short time horizon and was heavily destination and goal driven. Apollo was also launched at an almost perfect time, as it had strong backing from a pair of powerful Presidents at a time when the United States had money to burn on anything remotely related to defense spending. Additionally, the program was launched at the very heart of the “Space Race” and was widely seen as a way to “beat the Russians” to the Moon. At the time, the flaws in the Soviet Space Program were not yet apparent to most in the West, and there was a real concern that the Soviets were ahead. This fear created a panic, which both caused resources to flow into NASA and created a sense of urgency within the organization. Finally, the program was designed by a very small group before much of the bureaucracy was created, which allowed it to ignore the horrors of design by committee. The Apollo program succeeded in its original goals, but many of the follow up missions in the program were cancelled due to the desire of President Nixon to pursue the Space Shuttle and Skylab programs.

### **The Gemini Program: 12/40**

Gemini was a program designed to enable Apollo. It was one of the most efficient and goal driven programs ever to exist. The program was relatively low cost, technically simple, and had an extraordinarily short time horizon. It took place during, and as part of, the Apollo program, so it was very well timed. Of all the programs examined, Gemini has by far the best score on the graph. Gemini succeeded spectacularly and paved the way for the rest of Apollo.

### **The Grand Tour: 23/40**

Grand Tour was a NASA program which endeavored to utilize an extremely rare planetary alignment to send an unmanned probe to Jupiter, Saturn, Uranus, Neptune, and Pluto. This alignment was set to occur in the late 1970s and not reoccur for another 175 years. The Grand Tour was quite costly, but what truly ended it was the immense time horizon involved to build the ships and launch them to the outer solar system and the fact that the program had almost no defense applications. This essentially caused the Grand Tour proposal to fail, despite most other variables being relatively positive.

### **Skylab: 23/40**

Skylab was a NASA program to build the first long term American space station which set the standard for the Space Station *Freedom* concept, which eventually became the basis for the permanently manned International Space Station. Skylab started as a kind of post-Apollo “make-work” program for the various engineers and

scientists who had just landed on the Moon and as a proof of the theory demonstrating that humans could live and work in space (Benson and Compton, 1983). Skylab was quite expensive, had a relatively long time horizon, was technically complex, and began under a President in a much worse situation than the Apollo program. However, the space race was still “on” when the project was proposed and there had not been any serious failures or shortages in discretionary spending for quite some time. Essentially, Skylab was the last major “space race program” and probably wouldn’t have been successful if it had been proposed a few years later. The other serious issue with Skylab, and other missions proposed in 1973 like Viking and Voyager were that it was closely associated with Nixon, who had a very pro-low Earth orbit space policy. These programs originally benefited immensely since Nixon controlled Congress relatively effectively. However, during the middle of their appropriations process, the Watergate scandal went public and the American population lost all interest in space travel and Congress began specifically targeting programs Nixon had supported. Most were only saved by the need to “keep up with the Soviets.”

### **Viking: 20/40**

Viking was a program which landed the first two American probes on Mars, including the first probe to survive on Mars for longer than a few seconds. The program was the most expensive mission ever sent to Mars costing around 1 billion 1973 dollars. Despite the immense costs associated with the program, it was done remarkably quickly with only a few years between conception and landing. This short time line was one of

the primary reasons the mission was so successful and scored so efficiently on the scale. Additionally, the mission was able to get approval from Congress despite its ties to Nixon and to Watergate largely because the Soviets had already landed two probes on Mars, even if though said probes ceased operating after a few seconds. Essentially, this recreated a “mini-space race” which required NASA to land SOMETHING on Mars and have that something actually function for longer than a few seconds. Viking, like Skylab and Voyager, succeeded in part because the Soviet Union had challenged American technical accomplishments.

#### **Voyager: 20/40**

The Voyager program was a series of probes which continued the Grand Tour to a lesser extent by observing the outer planets up close. Both spacecraft are amazingly still operational and Voyager 1 has even left the solar system. Despite its expense and rapid delivery, however, Voyager was barely approved mainly due to a public lack of trust in the government following Watergate.

#### **Apollo-Soyuz: 28/40**

This program was essentially one which proved the utter futility of international space cooperation years before ISS took flight. As the first joint US-Soviet Spaceflight, its launch is widely considered to mark the end of the Space Race. It was originally intended as just the first in a series of joint US-USSR space efforts; however, it suffered from moderately high cost, immense technical complexities in joining two vastly



different spaceships, the classic “free rider” problem of international cooperation, and quite a bit of design-by-committee style micromanagement to make sure the United States “looked good” in front of the Soviets. This, combined with Soviet failures, made sure that the program never got beyond one, largely symbolic joint flight. The series of joint missions never materialized. These same problems would later rear their heads in the construction of the International Space Station.

### **Space Shuttle: 30/40**

The Space Shuttle is the quintessential example of massive resources being invested in a bad idea due to the sunk cost fallacy. The Shuttles were originally intended to provide easy, low cost orbital access to rapidly build up space infrastructure. For reasons discussed elsewhere, this failed spectacularly and the United States government ended up pumping billions of dollars into the program for years. The program itself, however, was remarkably successful from a political standpoint despite having a rather high aggregate score, particularly in the more important categories like cost, time horizon, technical complexity, and design by committee. This is mainly explained by the fact that it was more or less the only idea, at the time, which managed to get a lot of internal support both from NASA and other government branches. It is also worth noting that the original cost estimates and time projections were much lower than they became in the future. Ironically, since the Shuttle program gained a much greater degree of unifying support within the government than any space program with the possible exception of the International Space Station, this allowed initial costs and

procurements to move along without too much trouble. After the program became established and benefits started being doled out, it became politically impossible to cancel because Senators and Congressmen with jobs involved with it in their districts would fight to defend it. Essentially, the Shuttle program is proof that once a space program begins, it tends to take on a life of its own and become difficult to cancel.

#### **Space Exploration Initiative: 37/40**

As previously mentioned, SEI was an ideal example of how NOT to run a space program. It received by far the worst rating given by this thesis, receiving the worst possible grade in no less than 5 out of 9 categories. SEI was so bad in some of these areas that it literally altered the scale and made other projects look better by comparison. It failed spectacularly in the most important categories of relative cost, time horizon, technical complexity, design by committee, and the lack of a space race. NASA seems to have treated this particular program as a wish list for every plausible or conceived technology. The level of “gold plating” on the ship caused its detractors to refer to it as “Battlestar Galactica” after the popular science fiction show. The program quite simply presented an unmanageable design and its legacy continues to haunt NASA appropriations, especially those pertaining to Mars, in Congress to this day.

#### **Original ISS Proposal: 35/40**

The ISS program was essentially an extension of the Skylab and Apollo-Soyuz programs. It was intended as a sort of proof of concept, showing that the world could

work together in space. Not every country could meet its obligations and most had little incentive to do so since Congress kept bailing the program out. While there are numerous reasons why the ISS had so many issues, but essentially it boiled down to the various partners in the program falling victim to the “free rider” problem which led to massive cost overruns, time delays, and numerous technical problems. NASA was forced to work with four other space agencies, which led to complications with design by committee which surpassed even the Space Exploration Initiative. The idea of international cooperation defraying costs fell apart quickly, as the other nations supplied very little monetary backing. In the final tally of the \$150 billion invested in the station the Russian Federation spent \$12 billion, the European Space Agency spent \$5 billion, Japan spent \$5 billion, and Canada spent \$2 billion (Lafleur, 2010). Overall, the ISS achieved cheap and easy political support due to its international nature and the inherent tendency of Congress to support things with the word “international” in their name. This shows that international cooperation can be valuable in getting a program approved, but that NASA should not count on partners to keep their commitments.

### **Pathfinder: 20/40**

Pathfinder was an attempt to get NASA refocused on Mars in a way that was “cheaper, faster, and better.” It managed to avoid the worst of the political landmines by being relatively inexpensive, short term, and technically simple. Pathfinder actually managed to score perfectly in those areas. However, the program’s timing was ineffective in terms of discretionary spending and the Space Race. The ultra-cheap and

ultra-low risk nature of Pathfinder paid off, however, and went on to set the stage for the robotic and roving exploration of the Red Planet.

#### **MER Spirit and Opportunity: 25/40**

The Mars Exploration Rovers *Spirit* and *Opportunity* were in many ways larger versions of Pathfinder but were launched at an even worse time. They were much more difficult to sell as a defense program and the discretionary spending situation of the United States had worsened a great deal before they were launched. However, these rovers performed exceptionally well once they reached Mars and they set the tone for future missions like *Curiosity*.

#### **Vision for Space Exploration: 35/40**

The Vision for Space Exploration was in many ways the Space Exploration Initiative Junior, but at a somewhat worse time. It was tremendously expensive, distributed across a long time horizon, outlandishly technically complex, and it followed the dramatic destruction of Space Shuttle *Columbia* and serious issues regarding the power of the President and discretionary spending. The program also changed its stated goal from going to Mars to merely returning to the Moon. Additionally, it was proposed during the middle of its supporting President's term, and said President lost an enormous amount of Congressional control and prestige immediately following VSE for unrelated reasons. The failures of VSE are discussed at length elsewhere in the thesis.

### **MSL Curiosity: 29/40**

*Curiosity* is a currently active program which built off the extreme success of Spirit and Opportunity. Although the program was quite technically complex and a rather bad discretionary spending situation, the mission proposal was accepted. It landed successfully, and so far has proven to be enormously effective in its assigned mission. The program is more or less the last mission to Mars that has been approved by Congress.

## **Part 5: Changing the Method, Missions to Mars which are Achievable**

Consequently, the next phase for any future successful NASA mission is to carefully craft proposals to reenergize the American space program to become more politically feasible. This section will consider several of technological ideas for going to Mars to examine how politically workable they are compared to past programs. Then this section will cover potential methods of effectively funding these programs through the Congressional appropriations process.

### **The Fleet of Von Braun**

Warner Von Braun, a leading rocket scientist who after the defeat of Nazi Germany in World War II began working for the United States, was the first person to ever seriously consider sending humans to Mars. Von Braun planned a massive project to build between 2 and 10 spaceships in orbit the Earth using hundreds of launches to Low-Earth orbit to lift the necessary components. This massive fleet of spaceships would then fly to Mars, landing over a hundred astronauts on the Red Planet and enough supplies to keep them there for a year and a half. This idea that Mars would be explored by a large fleet of nuclear-powered spaceships built in orbit around the Earth, went on to influence the previously discussed Space Exploration Initiative. Future mission planners expressed a desire to “go big or go home,” just like Von Braun (Platoff, 2001). The political hurdle with this concept is that orbital assembly of the massive spaceships requires a massive build-up of orbital infrastructure like cryogenic fuel tanks, orbital factories, and orbital smelting facilities. This would require immense amounts of money,

very long mission time horizon, and the necessity of using nuclear power. As previously discussed, these obstacles would not be conducive to getting the mission funded by Congress. In fact, the legacy of the Von Braun plan is almost certainly one of the many reasons that NASA prefers high cost and long time horizon missions. The Von Braun style plan was the one used in both the Space Exploration Initiative and the Vision for Space Exploration. It is quite obvious that the failures of this mission plan damaged the chance of success for both programs.

### **Mars Direct:**

Mars Direct was an idea created by David Baker and Robert Zubrin, two engineers working at what is now Lockheed Martin, in an attempt to create an extremely simple, robust, and stripped-down mission to Mars. It is a short-time horizon, long stay, and, most importantly, inexpensive plan. The spacecraft used would be small enough to build entirely on the ground. This would make orbital assembly unnecessary, eliminating the need for orbital infrastructure like hangers, orbital factories, and cryogenic fuel tanks. This step alone would reduce costs considerably since it would cut Von Braun's 100 launches per mission down to 2 to 3 which would be immensely more efficient. This would be done by accepting a much smaller, 4 as opposed to 150, person crew and making each mission independent of external support. Another major simplification is Mars Direct's innovative idea regarding fuel. Normal missions like Apollo carry all the fuel for the trip back to Earth with them. This fuel is "dead mass" which erodes the

spacecraft's performance and is required to be lifted into orbit. Mars Direct has the fuel for the return spacecraft manufactured on Mars. Essentially, when the astronauts land, there will already be a fully fueled return ship on Mars before the astronauts ever left Earth. The ship the astronauts came in can simply be left on Mars and be used as a stationary science platform or the beginning of a Mars base. This sort of redundancy, which occurs quite frequently in the mission, actually makes Mars Direct much safer than the traditional Von Braun plan despite its smaller crew complement (Zubrin, 2011). The most significant objections with the plan are psychological and sociological in nature. Most psychologists and sociologists believe that no group of 4 people can handle isolation for the time required to get to Mars and back (Kanas and Manzey, 2008).

Mars Direct was scored by the CBO and was estimated to cost roughly \$30 billion (Zubrin, 2011). The time horizon is generally estimated to be approximately 10 years. This is significantly shorter than the majority of proposed ideas because it does not require any new technology to be developed. Mars Direct calls for the crew to remain on the surface of Mars for a little over 500 days while they wait for the return launch window to open because the mission would be launched at conjunction, not opposition, which would necessitate a longer mission with more time on Mars. Essentially, when going to Mars, an astronaut can either return in 30 days or return in 500 days due to the orbits of Earth and Mars. Mars Direct would actually allow for more time exploring Mars than other mission designs like SEI, VSE, or other Von Braun plans since any mission to the Red Planet would take roughly 6 months to get there. After all, if astronauts are



spending that much time in space, they might as well have time to do some useful scientific work once they reach Mars. Additionally, spending 500 days on Mars would allow for a much more leisurely return trip requiring a less powerful engine and not requiring a dangerous “Venus Fryby” like the (Armstrong, Zubrin, Baker, 2007.)

Overall, Mars Direct is an excellent “slimmed down” Mars mission which succeeds because it eliminates extraneous portions of the mission. It is the exact opposite of programs like the Space Exploration Initiative and the Vision for Space Exploration. However, the things that make Mars Direct an engineering, scientific, and political success with Congress make it a difficult sell with the internal NASA bureaucracy. The initial push for Mars Direct was defeated within NASA by a combination of research teams supporting the Space Station and the advanced propulsion teams. These in-house organizations managed to effectively redirect the Mars mission into what became the Vision for Space Exploration. Mars Direct didn’t need either team, so they fought it. “Pork in space,” or deeming each group’s pet technology mission critical, is certainly the most effective way to pass a mission through NASA’s internal approval structure. Due to this, a Mars Direct style mission needs to be “porked up” to pass through NASA.

### **Mars Semi-Direct/Design Reference/Red Dragon:**

The various redesigns of Mars Direct to appease internal forces in NASA and the private spaceflight community took place over a period of several years. The first of them, Mars Semi-Direct, was essentially an attempt to make the original program bigger and “flashier,” so it could go through the NASA approval process. Semi-Direct had its heyday in the aftermath of the disaster that was the Space Exploration Initiative. NASA was looking to reduce costs of future missions and was thus willing to at least consider dramatically simplified solutions to the Mars program. In the end, Mars Semi-Direct increased the cost of the mission, but had more launches, a larger crew, and more equipment for that crew. The Design Reference Mission which was the ultimate child of Semi-Direct was estimated to cost around \$55 billion dollars, which could be done within NASA’s existing budget (Zubrin and Weaver, 1993). The cost reductions were proven to work relatively effectively as many of the ideas of Mars Semi-Direct were partially responsible for the significant cost reductions in the Vision for Space Exploration, though that mission plan certainly didn’t incorporate all the cost reductions possible. This is especially evidence when compared to the original Space Exploration Initiative cost estimates which ranged from \$450-500 billion dollars. The Design Reference Missions continually revised the Vision for Space Exploration to make it less costly and more efficient while still meeting the various internal requirements of NASA. Towards the end of the Vision, the Design Reference Mission essentially was the plan for the Mars portion of the mission. These changes were enough to ensure passage through

the internal political structure of NASA, but the Design Reference Missions were strongly politically linked to the Bush Administration's Constellation program due to their connection with the Vision.

When the Obama administration came into power in 2008, the attack on Constellation was virtually guaranteed. After the stimulus spending of 2009, the Obama administration eliminated virtually the entirety of the Constellation program. The program's funding was denied in 2011 by the Obama administration and the Constellation program ended and with it the last vestiges of the Vision for Space Exploration. Yet, somehow, this was done without managing to save any money in the NASA budget whatsoever. In 2008, NASA spending was \$17.4 billion, while NASA's 2012 budget was \$17.7 billion (Fiscal, 2013). However, this gets worse considering the fact that in 2008, NASA was running an active space-shuttle program, saving the Hubble Space Telescope, developing Constellation which would return humans to the Moon by 2019, building *Curiosity*, and planning several probes to the outer solar system (Zubrin, 2012). But, by 2012 all of these programs were no longer a factor and NASA hasn't created any serious new programs since the Vision. However, NASA is still getting more or less the same amount of money in inflation-adjusted terms. In fact, its Mars missions seem to be permanently on the back burner.

However, the American government's space program is not the same as the American people's space program. Recently, private American companies have been

making enormous strides into space. The most notable accomplishment by private space to date was the docking of the SpaceX Falcon rocket at the International Space Station (Follett, 2012). SpaceX has expressed interest several times in doing a Mars mission if a sponsor can be found for the mission. SpaceX's Red Dragon plan is a modified capsule which would cost an estimated \$425 million dollars. That is incredibly cheap by the standards of space exploration. To put that cost in some perspective, the Mars Science Laboratory *Curiosity* rover required \$2.5 billion and did not return a sample to Earth (Wall, 2011). Red Dragon could easily be modified from a sample return mission to carry an actual human crew to Mars. The idea of having a private corporation pave the road to Mars for governments will be discussed more in future sections.

### **Mars for Less:**

Mars for Less is a theoretical mission, designed by NASA, which correctly assumes that a significant percentage of mission cost comes from attempting to develop and design a new launch vehicle for every potential mission. The proposal essentially builds on Mars Semi-Direct and the Design Reference Mission, but attempts to dramatically slash costs by cutting numerous essential components and greatly reducing the redundancy inherent in the Mars design. The idea was once described as “safety second, cash first” by many observers (Bonin, 2006). Obviously the potential for a public relations disaster is immense and cutting safety isn’t the best PR move, but the cost reductions would immensely simplify the program and permit private corporations and individuals to enter the “market.”

Essentially, the proposal reduces costs even further than Mars Direct by using multiple existing smaller launch vehicles to reduce developmental costs on the new large launch vehicles. Theoretically, this would also reduce the time horizon necessary for the mission, making it more likely to be funded (Zubrin and Wagner, 2011). Essentially, Mars for Less would reduce costs by reducing the size of the ships sent, the number of crewmen sent, and sharply cutting down on the number of supporting launches (Bonin, 2006). This, however, creates some technical issues, specifically in regards to aerobraking in the Martian atmosphere which would be much more dangerous. The proposal is interesting, nevertheless, as it clearly holds the potential to

dramatically reduce costs. However, the resulting public outcry from a program which would place “safety second” would probably doom a government mission. A privately funded mission though may very well end up selecting Mars for Less.

### **Mars to Stay:**

The hardest part of going to Mars is getting back to Earth. But what if the first astronauts to go to Mars never came back? Despite what most people think, a one-way mission to Mars wouldn't be a suicide mission. It is perfectly possible for humans to live on Mars for extended periods of time. In many ways, colonization of the Red Planet is in many ways far more practical than visitation.

The plan has proven to be oddly popular with some segments of the general public, probably due to its "celebrity" endorsement by Buzz Aldrin, the second man to walk on the Moon. The plan basically revolves around the idea that sending a colonization effort, not an exploration effort, to Mars would ultimately be both cheaper and safer. A one-way trip has a number of technical advantages, not the least of which is the fact that the spacecraft wouldn't need to carry fuel for a return journey and the crew's radiation exposure would be halved. Since the most dangerous parts of any spaceflight are the launches and the landings, this means that not coming home to Earth would make a one way mission ironically far safer than a "there and back again" mission. Additionally, a long-term colonization would allow for astronauts to spend more time actually conducting experiments on the Red Planet on a per launch basis (France-Presse, 2008). In Dr. Aldrin's own words:

If we aspire to a long-term human presence on Mars—and I believe that should be our overarching goal for the foreseeable future—we must drastically change our focus. Our purely exploratory efforts should aim higher than [the Moon] a

place we've already set foot on six times. In recent years my philosophy on colonizing Mars has evolved. I now believe that human visitors to the Red Planet should commit to staying there permanently. One-way tickets to Mars will make the missions technically easier and less expensive and get us there sooner. More importantly, they will ensure that our Martian outpost steadily grows as more homesteaders arrive. Instead of explorers, one-way Mars travelers will be 21st-century pilgrims, pioneering a new way of life. It will take a special kind of person. Instead of the traditional pilot/scientist/engineer, Martian homesteaders will be selected more for their personalities—flexible, inventive and determined in the face of unpredictability. In short, survivors (Aldrin, 2009).

The plan was brought to the attention of the general public in 2004 when an opinion piece supporting it appeared in the *New York Times* (Davies, 2004). The first article was written when the Vision for Space Exploration looked like it might actually occur. The op-ed generated a lot of hype for the plan, but due to the obvious political difficulties inherent in leaving astronauts on Mars to stay without a great deal of support from Earth, the plan was left out of the Vision. In 2009, just in time for the 40th anniversary of the Moon landings, the *New York Times* published another opinion piece supporting the Aldrin model for Mars exploration (Krauss, 2009). Both articles drew the comparison between the settlement of Mars and the settlement of the New World and managed to immensely improve the popularity of this model for Mars exploration that might be considered inherently hard to sell. Mars to Stay is an extremely attractive option from the standpoint of reducing time horizon, monetary costs, and technical



complexity. However, it creates the public relations nightmare of the astronauts simply not returning home. This would provide the political opposition to such a program with the opportunity to claim that the program was a “suicide mission.” This mission concept can be summed up by simply saying “Forget the Moon, Let’s Head to Mars!” or “Traitors Return to Earth!”

## **Part 6: How to Do Mars Politically**

Most nations on the world dislike the United States for various reasons. America is the most dominant nation on Earth, but in the minds of the rest of the world, the face of that dominance is a *Predator* drone or an American corporation tapping natural resources. In the late 1960s, the United States did something generous and uplifting for all mankind. The Apollo program was widely seen as a great triumph of man over nature and it massively increased American “soft power” for quite some time. Apollo caused the rest of the world to consider America to be the leader in technological innovation and just about everything else. Today, we have the technological capability to send the first representatives to walk on another planet. This would essentially cement the vision of America as a technological innovator into the minds of the world. Such a feat would be an astonishing gift for all mankind and would certainly improve life in the United States. This section of the thesis is dedicated to determining, not the mistakes NASA has made in the past, but ways in which NASA could improve its marketing and succeed in getting missions funded in the future.

As previously discussed, the greatest obstacles to a manned mission to Mars are political, rather than technological or economic in nature. Therefore, they require politically workable solutions. These solutions essentially divide into five different “models.”

## **JFK Model**

The JFK model, named for its biggest advocate and supporter, is the most widely understood and accepted political method for getting a Mars mission to occur. Essentially, it relies heavily on a proactive and involved President who spearheads the program through Congress. This method worked outstandingly well for the Apollo program since both JFK and LBJ were heavily invested in its success and were powerful political forces in their own right. These Presidents were so successful that the NASA budget peaked at roughly 4% of federal spending (Zubrin and Wagner, 2011). However, this method failed miserably during the Presidencies of both Bushes since neither was particularly committed to their respective programs. Moreover, it is not clear at all that the nationalistic foundations which supported the Apollo program still exist in the current cultural and political climate, largely due to the lack of a Soviet Union or equally powerful adversary for the United States. But, if a highly supportive President were to be elected, the JFK model is a proven success and could potentially result in a very effective and “low score” mission. Furthermore, NASA can do virtually nothing to ensure the election of a pro-space President, so perhaps it would be better to create a mission design which would ensure a broader base of political support.

## **Sagan Model**

The Sagan model, named after its biggest advocate and public voice, promoted Mars as a kind of super team-building exercise for the international community. Carl Sagan saw a joint American/Soviet Mars mission as a way to tie two competing nations together in a joint undertaking. Sagan, however, was far from the only person to call for this. Virtually every blue-ribbon panel on space exploration has put forward an idea for international cooperation in space. Theoretically, an international space effort would be much more affordable due to the ability to disperse costs and share resulting technologies among numerous members. The European Space Agency has proven to be a highly effective example of this in recent years. However, as the previously discussed and much attacked International Space Station proves, international projects add an entirely new set of problems. For example, partners in the program can end their involvement for virtually no reason, or hold hostage their cooperation on the program to political whims. The loss of any partner, or the simple failure of a partner to deliver on its promises, can be disastrous to the mission timetable. Delays in space program schedules tend to cascade, and doom entire missions. Crew selection and crew languages also would prove to be an immense problem over any long period of time. Technological collaboration would also be a nightmare as most space programs utilize technologies which the supporting governments wouldn't want revealed to their fellow contributors. This particular issue has reared its ugly head even in the very friendly relationship between NASA and the ESA. If Americans and Europeans cannot cooperate and share technology, it is unlikely in the extreme that Russians, Chinese, and Americans

will be able to do so in an effective manner. Ultimately, international cooperation makes it far easier to pass a bill through Congress, but it ironically makes the mission far more difficult than it would be otherwise, since it increases the technical and political complexities involved. After all, dealing with just the American government is hard. Dealing with the American, Russian, European, Japanese, and Canadian governments is nearly impossible. Perhaps small scale “feel good” collaboration between very friendly countries may produce results in the future, but broadly speaking the differences of nations are much more likely to be exacerbated than healed over by the rigors of space travel.

### **Zubrin/Gingrich Model:**

Robert Zubrin, one of the creators of the Mars Direct mission style, developed this method in conjunction with former Speaker of the House Newt Gingrich as a way to reduce the price tag of missions to Mars by outsourcing some of the costs. Essentially, this method boils down to the United States Government posting a 20 billion dollar “super X prize” for the first organization to successfully land a human on Mars and return him or her to Earth. The winner would receive a considerable amount of money, and a valuable contract to provide the vehicle used for the mission to NASA. This method has a number of advantages over traditional ideas since, if the mission isn’t accomplished, American taxpayers don’t pay a dime. After all, the government doesn’t have to release the prize money unless the mission is accomplished. Since the organization in question would be spending its own money and investing to get the prize, the overall costs of the mission would undoubtedly be lower as well because the organization’s profit would be the prize minus the costs. After all, it’s a lot easier to opt for a cheaper solution to engineering issues when one’s own money is at stake. Finally, getting relatively outside the political system would allow the program to ignore issues like discretionary spending problems, Presidential control over Congress, and NASA’s internal in-fighting issues.

The idea of private prizes for accomplishments in civil aviation is not a new one. In fact, Charles Lindberg flew the Atlantic Ocean in pursuit of the privately funded Orteig prize (Bak, 2011). Private prizes in space have historically proven to be very successful.

The most famous example of this was the \$10 million dollars Anasari X Prize rewarded to the first non-governmental organization to launch a reusable manned spacecraft into space twice in two weeks. It was created in May of 1996 and was won on October 4, 2004 by Burt Rutan's *SpaceShip One*. The Prize succeeded in creating over \$100 million dollars in investment by private corporations and individuals. It was a masterful success by every possible metric, and it didn't cost taxpayers anything. Another prize which is a bit more comparable to a potential Zubrin/Gingrich plan is the Google Lunar X Prize. This is a \$20 million dollar prize for landing the first privately funded rover on the Moon and having that rover travel more than 500 meters. An additional \$5 million dollars is promised to the second place rover with another \$5 million for the accomplishment of various technical tasks. Presently, there are 29 different companies officially competing for the prize and several prototype landing systems have been tested. A large Zubrin/Gingrich style "Mars Prize" of \$20 billion dollars for a landing and \$10 billion for various technical challenges could easily be backed by the federal government. The most marketable thing about a "Mars Prize" system is that the money isn't spent unless the mission is accomplished. Since \$30 billion dollars is a lot of money when spent outside of the government, it would almost certainly be enough to encourage investors. However, \$30 billion is a lot of money for a space program even if its orders of magnitude are better than the \$450 billion dollar monstrosity of SEI (Zubrin and Wagner, 2011). Additionally, none of that would be going to NASA and associated "pork" projects. This small challenge could probably be worked around though by requiring any group which wins the prize to do some political appeasement such as

manufacture a majority of their craft in the United States and encouraging participants to use NASA launch/deep space tracking facilities to appease the NASA bureaucracy.

The “prize” model has never been attempted on anything like this scale, and therefore it is much more speculative than the JFK or Sagan models. It does, nonetheless, seem to hold great potential for use in human spaceflight.



## **Mars One Model**

Mars One is an excellent and original idea based around the belief that any Mars mission which cannot support itself financially once on the Red Planet would ultimately be doomed. This has been true historically considering various colonies. Jamestown, Virginia, for example, was never successful and was constantly in danger of losing support until it produced a valuable product, tobacco, which it could economically export to the Old World. The Mars One idea was originally conceived by Dutch entrepreneur, Bas Lansdorp, and would use the Mars to Stay mission concept to reduce mission costs. Interestingly, the mission would be funded by documenting the mission preparation and selection processes in the form of a reality TV show. This would continue when the crew reached Mars becoming “Big Brother in Space” (Waugh, 2012). Mars One would allegedly be an entirely private and apolitical venture funded by a private corporation interested in profit. It is certainly worth noting that a great deal of colonization of the New World was done by private corporations interested only in profit.

Obviously the idea of “Big Brother in Space” has several serious issues, most notably the simple fact that good astronauts most likely will not make good reality TV contestants, which will ultimately lead to a decrease in public interest. However, the idea of “Space for Profit” brought up by Mars One is highly intriguing since it would allow access to Mars by organizations only subject to the laws of economics, not political whims. Ultimately, if Mars is incapable of producing something of economic

value, any attempt at colonization will be relatively futile. However, a great deal has already been written on the economic viability of Mars in Zubrin's book, *The Case for Mars*.

### **Tito Model**

In the early years of the 20<sup>th</sup> century many visionaries, particularly science fiction writers, imagined that mankind's expansion into space would be funded by eccentric rich guys and crowd sourcing, much like the rise of civil aviation. In fact, in Jules Verne's *From Earth to the Moon* the mission is funded by voluntary contributions by individuals. Many wealthy individuals have expressed strong interest in spaceflight and have started to put real resources into private space companies. In February<sup>1</sup> of 2013, multimillionaire space tourist Dennis Tito announced his intention to launch a privately funded "free return" mission to Mars in January of 2018. It is worth noting that this mission would not actually land humans on Mars. The cost estimates are in the 2.5 billion dollar range. The low cost of a mission like this could be funded by private individuals and non-profits.

### **Conclusions:**

Both governmental and non-governmental organizations will certainly attempt to create missions to the Red Planet over the next several years. Both the way these missions are structured and the timing of the launch are immensely important to the mission's successful passage through Congress, the NASA bureaucracy, or any other approval body. If NASA wants to launch a manned mission to Mars, they should give serious consideration to eliminating inefficiencies in their mission architecture and timing the mission properly in a political sense.

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